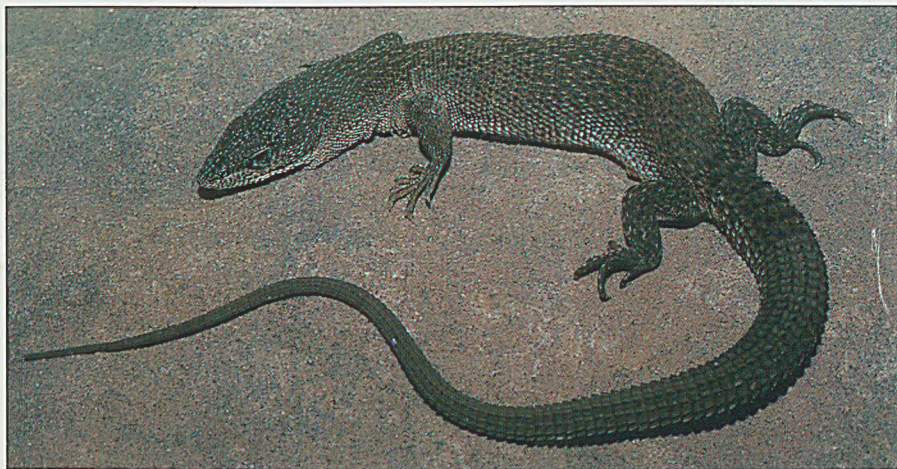


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A Northern Bluntspined Monitor *Varanus primordius*. See paper on page 126. (Photo: G. Husband)



A Short Tailed Pygmy Monitor *Varanus brevicauda*. See paper on page 92. (Photo: R. Jackson)

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SURVEYS OF REPTILES AND AMPHIBIANS AT RAZORBACK NATURE RESERVE, KEVERSTONE STATE FOREST AND THE ABERCROMBIE CAVES REGION OF NEW SOUTH WALES.

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ABSTRACT

A survey of the reptiles and amphibians on the central tablelands of New South Wales recorded 22 species of reptile and 9 species of frog. One species, the Booroolong Frog *Litoria booroolongensis*, is currently listed on Schedule 1 of the Threatened Species Conservation Act (1995) of NSW as Endangered. Dead and sick frogs were found infected by the amphibian chytrid fungus. Several species detected during the survey represent range extensions.

INTRODUCTION

Fauna surveys of Razorback Nature Reserve (2595 hectares) and Keverstone State Forest (2740 hectares) (Fig.1) were conducted as part of the southern Comprehensive Regional Assessment (CRA) to investigate the adequacy of the current reserve system in New South Wales. Reptiles and amphibians were surveyed systematically. Survey sites were stratified according to rainfall, temperature and geology. Targeted and opportunistic surveys were also conducted (Abercrombie Caves area) to provide a more comprehensive survey of the region's herpetofauna.

In this paper we describe the reptile and amphibian community of these areas on the New South Wales central tablelands, and make particular comment on the Endangered Booroolong Frog.

STUDY SITES

The geology varied between the survey areas. In Razorback Nature Reserve (NR) the substrate was metamorphic rock. In Keverstone State Forest (SF) there was mainly thin

siliceous soils and granite outcrops, while the Abercrombie Caves area had metamorphic rock and limestone outcrops. The range of altitude for the survey areas were Razorback NR: 540-840 m asl, Keverstone SF: 680 - 1000 m asl and Abercrombie Caves: 580 - 700 m asl.

All three habitats primarily consisted of woodland, which had sparse understorey and ground cover. Common dominant canopy species of Razorback NR were Scribbly Gum *Eucalyptus rossii*, Bundy *E. goniocalyx* and Red Box *E. polyanthemus* on the ridges and slopes and small areas of Apple Box *E. bridgesiana* and Blakley's Red Gum *E. blakelyi* at the reserve boundary in the gully flats. The forests had been selectively logged and old growth elements such as stags, hollow bearing trees and large fallen logs were uncommon.

The vegetation of Razorback NR was not representative of the area as a whole. The more gently sloping and fertile areas outside of the nature reserve had been preferentially cleared for agriculture. Remnant vegetation on surrounding farms consisted of grassy woodlands mostly dominated by Yellow Box *E. melliodora*, White Box *E. albens* and Apple Box.

The vegetation of Keverstone SF differed from that of Razorback NR due to differences in geology and topography (the State Forest was in relatively flat country compared to the Nature Reserve). The woodland typically had greater grass groundcover and was dominated by Red Stringybark *E. macrorhyncha* and Bundy on ridges and slopes again with small occurrences of Blakley's Red Gum and Apple Box along drainage lines. Dense patches of

Tea-tree *Leptospermum* spp. and Cypress Pine *Callitris endlicheri* occurred in areas of wet sandy soil and granite outcrops respectively.

Dominant canopy species at Abercrombie Caves were Apple Box and Yellow Box with a belt of mature River Oak *Casuarina cunninghamii* along Grove Creek. The grassy understorey was heavily infested with weeds and native shrubs were sparse. Sections of Grove Creek had rocky races (riffle areas) and areas of midstream exposed rocks. Grove Creek had a gentle gradient and the survey areas were above a large waterfall (approximately 80 metres).

In areas of Keverstone SF and Abercrombie Caves there were granite outcrops which contained loose rock on rock. This was significant because many species of reptile are saxicolous (live among rocks). The absence of this habitat type in Razorback NR influenced the species diversity of reptile which occurred in the reserve.

METHODS

Fauna surveys were conducted from 3-9 December 1998. The methods follow those determined by the NSW National Parks and Wildlife Service for the purpose of the southern CRA process (NPWS, 1998). These included standard site-based and targeted survey methods and incidental records. In conjunction with site-based surveys, a set of site attributes (physical, floristic and structural variables) was collected.

Survey sites (transects) were either in a gully, ridge and midslope. The selection of a gully, ridge and midridge attempted to sample a variation in habitat based on moisture gradients. Seven sites were surveyed in Razorback NR. Sites were separated by at least one kilometre. A steel dropper was placed at the start of each site to provide a long term marker. The majority of sites were photographed and a min-max thermometer was placed at the start of each transect. Standard surveys were based around a 2 ha (100 x 200 m) site. Pink

flagging tape was placed at 20 m intervals along the centre of the transect.

A 0.5 ha subset of each site was surveyed for reptiles. The census involved two persons surveying for 30 minutes each (a total of 60 minutes search effort). Surveys were conducted between 4 - 6 December 1998 between 9.20 - 13.00 EST at temperatures that ranged from 23 - 28°C. Two targeted surveys for reptiles were conducted on 7 December 1998 (sites 72 and 84) in Keverstone SF. These sites were in gently undulating areas, which had rock outcrops. Due to time constraints site 84 was surveyed by two people for a total of 40 minutes between 15.40 - 16.00 EST.

During reptile searches active animals were observed as they basked or foraged. Inactive animals were located by lifting loose rock, logs and decorticated bark and searching leaf litter. Animals were identified by sight and generally were not caught.

Frogs were surveyed at the two gully sites at night by spotlighting (12 v, 50 watt lights) for a period of 30 minutes along each of the 200 m transects. Frogs were either observed, identified by their calls and/or the morphology of tadpoles. Frog surveys were conducted on 3-6 December 1998 between 20.46 - 23.00 EST at temperatures which ranged from 15 - 22°C. Freshwater fish were identified during the frog surveys.

Two targeted surveys were conducted at night for frogs along different sections of Grove Creek. Two people conducted these surveys on 7 and 8 December 1998 between 20.54 and 21.44 EST at 22°C. The latter site was revisited during the day on 9 December 1998. One targeted survey was conducted for frogs in Keverstone SF (73) on 6 December 1998 between 22.30 and 23.00 EST.

In addition to the standard surveys, cage trapping was conducted along five transects which were located in gullies. Each transect had five large cage traps set for ten consecutive days, between 27 November and 7 December 1998, at twenty metre intervals.

The traps were baited with chicken, placed beside logs and wrapped with black plastic to protect captured animals from the elements. The ground was cleared and levelled where the traps were placed and were rebaited when necessary.

Additional observations of animals were made outside the systematic and targeted surveys. These observations occurred while driving between sites, at sites outside the dedicated period for systematic or targeted surveys or at additional sites. The position (Australian Map Grid Reference) of species detected during these periods was recorded.

RESULTS

The herpetofauna that had previously been detected in the area were determined by a search of the NSW NPWS Atlas of NSW Wildlife database. This source revealed records of 4 frog and 9 reptile species. The

current survey detected 9 frog and 22 reptile species.

A total of nine species of reptile and six species of frog were detected during the systematic and targeted surveys (Table 1 and 2). Opportunistic detections revealed the presence of an additional thirteen species of reptile and three species of frog (Table 3 and 4). The larger skinks and snakes were observed opportunistically during drive transects or caught in cage traps. The Snake-necked Turtle *Chelodina longicollis* was observed in a farm dam.

Eleven Shingleback *Trachydosaurus rugosus*, one Common Bluetongue *Tiliqua scincoides* and two Echidna *Tachyglossus aculeatus* were caught in the cage traps. Cage trapping success was 56%.

A higher species diversity of reptile was found at sites that contained rock outcrops or loose

Table 1. Reptiles detected at systematic and targeted sites.
Site numbers relate to CRA listing. R = ridge, M = midridge and G = gully.

Species		Sites									
		36R	36G	37R	37M	37G	38R	38M	72	84	
<i>Christinus marmoratus</i>	Marbled Gecko						1			1	
<i>Diplodactylus vittatus</i>	Stone Gecko						1			1	
<i>Amphibolurus nobbi</i>	Nobbi Dragon									1	
<i>Egernia striolata</i>	Tree Skink	1		1					1	1	
<i>Hemiergis decresiensis</i>	Three-toed Skink					4		3		1	
<i>Lampropholis delicata</i>	Grass Skink	1	2	1	1		10		5		
<i>Lampropholis guichenoti</i>	Garden Skink		8	2		1					
<i>Lerista bougainvillii</i>	Bougainville's Skink				1		1			1	
<i>Morethia boulengeri</i>	Boulenger's Skink	1		1			1				
Total Species		3	2	4	2	2	5	1	2	6	

rock. These sites were mostly ridgelines and site 84. There was a slight difference in the overall species diversity of reptiles found at Razorback NR and Keverstone SF (13 vs. 11 species). However, there were differences in the species composition. Bearded Dragon *Pogona barbata*, Eastern Water-skink *Eulamprus quoyii*, Garden Skink *Lampropholis guichenoti* and Boulenger's Skink *Morethia boulengeri* were found at Razorback NR and not Keverstone SF. The Jacky Dragon *Amphibolurus muricatus* and Copper-tailed Skink *Ctenotus taeniolatus* were found at Keverstone NR and not Razorback SF.

The geckoes *Christinus marmoratus*, *Diplodactylus vittatus* and Tree Skinks *Egernia striolata* were found under fallen timber, under decorticating bark or under piles of rock. The Nobbi Dragon *A. nobbi* and most of the Grass Skinks *Lampropholis delicata* and Garden Skinks were observed as active animals. The fossorial skinks were found under logs and partially buried rocks.

The low diversity (four species) of reptile found at Abercrombie Caves was a reflection of the limited search effort. The Gippsland Water Dragon *Physignathus lesueurii howittii*,

Wall Skink *Cryptoblepharus virgatus* and Cunningham Skink *Egernia cunninghami* were found here but not at the other survey sites.

Spotlight surveys along Grove Creek (Abercrombie Caves) revealed the presence of the Gippsland Water Dragon. Several female and two adult males were caught. The males had blackish throats streaked with orange and black chests, colour diagnostic of the subspecies *howittii*.

Only two sites had suitable habitat for nocturnal streamside searches, 36G and 37G. Tadpoles of Pobblebonk *Limnodynastes dumerilii* were observed in pools at 36G. There was no free water at 37G. Small Rainbow Trout *Oncorhynchus mykiss* and Yabbies *Cherax destructor* were observed at targeted site 80, in Razorback NR, with tadpoles of Pobblebonk and Common Eastern Toadlet *Crinia signifera*. Six species of frog were detected during these surveys (Table 2). The water level in the creeks surveyed fell during the time of the survey and became isolated pools.

Spotlight surveys were conducted at two sites

Table 2. Frogs detected at systematic and targeted sites. Site numbers relate to CRA listing. f = observed frogs, t = observed tadpoles, h = heard calls

Species	Sites							
	36G	37G	73	80	Grove Ck 1	Grove Ck 2		
<i>Litoria booroolongensis</i> Booroolong Frog					2(f)	10(f)		
<i>Litoria</i> sp. affin. <i>lesueuri</i> Lesueur's Frog					8(f)	16(f)		
<i>Crinia parainsignifera</i> Plains Froglet			5(h)		1(h)			
<i>Crinia signifera</i> Common Eastern Froglet			1(h)	1(f)	4(h)			
<i>Limnodynastes dumerilii</i> Pobblebonk	t		1(f)	t	1(f)	1 (f)		
<i>Limnodynastes tasmaniensis</i> Spotted Grass Frog			5(h)					
Total Species	1	0	4	2	5	3		

along Grove Creek. No exotic species of fish were observed. A total of 12 Booroolong Frogs *Litoria booroolongensis* (Fig.3) were found, two at Abercrombie Caves and ten at a second site approximately two kilometres downstream. Male frogs sat on rocks within the creek and called. One dead Booroolong Frog was found in the water. This animal was frozen for pathology tests.

Fifteen male and one female Lesueur's Frog *Litoria* sp. aff. *lesueuri* (Fig.2) were observed at the second survey site along Grove Creek. The male frogs were mostly positioned on the edge of the creek on rocks, near still or gently flowing water. One female found under the water was thin and had ulcerated skin. The frog exhibited lethargic behaviour and poor motor skills. This animal was also frozen for pathology tests. Both specimens were identified as having amphibian chytrid fungus using a wet preparation mount (D. Hunter pers. comm.).

Two clutches of frogs eggs were located on 9 December 1998 close to where the male Booroolong Frogs were concentrated. Spawn was located midstream, suspended 25 mm below the water between rocks. The gelatinous egg masses were laid in a water depth of 20 cm and adhered to rocks. There was a

steady movement of water around the masses. The egg complement of one clutch was 2041.

One clutch was partially hatched and upon disturbance the tadpoles sank to the creek bed. The tadpoles were washed between the spaces between the pebbles.

Nocturnal surveys at a fire dam in Razorback NR revealed the presence of Red-bellied Black Snake *Pseudechis porphyriacus*, Peron's Tree Frog *Litoria peronii*, Common Eastern Froglet, Plains Froglet *Crinia parinsignifera*, Spotted Grass Frog *Limnodynastes tasmanianensis* and Smooth Toadlet *Uperoleia laevisgata*. During the survey a Black Snake was observed for some 15 minutes on the edge of a fire dam. The snake captured and ate a Peron's Tree Frog during that time. Two pairs of Peron's Tree Frog and one pair of Smooth Toadlet were found in amplexus.

The following species were heard calling from beside farm dams near Razorback NR: Broad-palmed Frog *Litoria latopalmata*, Common Eastern Toadlet, Plains Froglet, Spotted Grass Frog and Smooth Toadlet. Table 4 lists all species of amphibian recorded during the current survey and also previous records from the region.

Table 3. Reptiles of Razorback NR, Keverstone SF, Abercrombie Caves region. o = observed during survey, p = previously recorded in area (NSW NPWS database), R = Razorback NR, K = Keverstone SF, A = Abercrombie Caves, F = freehold land adjacent to reserves.

Family	Species	Common Name	R	K	A	F
Chelidae	<i>Chelodina longicollis</i>	Eastern Snake-necked Turtle				o
Gekkonidae	<i>Christinus marmoratus</i>	Marbled Gecko	o	o		
	<i>Diplodactylus vittatus</i>	Stone Gecko	o	o		
Agamidae	<i>Amphibolurus muricatus</i>	Jacky Dragon		o		p
	<i>Amphibolurus nobbi</i>	Nobbi Dragon	o	o		
	<i>Physignathus lesueurii</i> <i>howittii</i>	Gippsland Water Dragon			o	
	<i>Physignathus lesueurii</i>	Water Dragon				p
	<i>Pogona barbata</i>	Bearded Dragon	o			

	<i>Tympanocryptis diemensis</i>	Mountain Dragon					p
Scincidae	<i>Cryptoblepharus virgatus</i>	Wall Skink			o		
	<i>Ctenotus taeniolatus</i>	Copper-tailed Skink			o		
	<i>Egernia cunninghami</i>	Cunningham's Skink				o	
	<i>Egernia striolata</i>	Tree Skink		o	o		
	<i>Eulamprus quoyii</i>	Eastern Water-skink		o		o	p
	<i>Hemiergis decresiensis</i>	Three-toed Skink		o	o		
	<i>Lampropholis delicata</i>	Grass Skink		o	o		p
	<i>Lampropholis guichenoti</i>	Garden Skink		o			p
	<i>Lerista bougainvillii</i>	Bougainville's Skink		o	o		
	<i>Morethia boulengeri</i>	Boulenger's Skink		o			
	<i>Saproscincus mustelina</i>	Weasel Skink					p
	<i>Tiliqua scincoides</i>	Common Bluetongue				o	
	<i>Tiliqua nigrolutea</i>	Blotched Bluetongue				o	p
	<i>Trachydosaurus rugosus</i>	Shingleback		o	o	o	p
	<i>Pseudechis porphyriacus</i>	Red-bellied Black Snake		o	o	o	
	<i>Pseudonaja textilis</i>	Eastern Brown Snake				o	
Totals				13	11	4	6 9

Table 4. Amphibians of Razorback NR, Keverstone SF, Abercrombie Caves region.
o = recorded during survey, p = previously recorded in area (NSW NPWS atlas), R = Razorback NR, K = Keverstone SF, A = Abercrombie Caves, F = freehold land adjacent to reserves.

Family	Species	Common Name	R	K	A	F	
Hylidae	<i>Litoria booroolongensis</i>	Booroolong Frog			o		p
	<i>Litoria latopalmeta</i>	Broad-palmed Frog				o	
	<i>Litoria</i> sp. affin. <i>lesueuri</i>	Lesueur's Frog			o		
	<i>Litoria peronii</i>	Peron's Tree Frog	o	o			
Myobatrachidae	<i>Crinia parinsignifera</i>	Plains Froglet	o		o	o	p
	<i>Crinia signifera</i>	Common Eastern Froglet	o		o		p
	<i>Limnodynastes dumerilii</i>	Pobblebonk	o	o	o		p
	<i>Limnodynastes tasmaniensis</i>	Spotted Grass Frog	o	o		o	
	<i>Uperoleia laevisgata</i>	Smooth Toadlet	o			o	
Total			6	3	4	4	4

Note: *Litoria* sp. affin. *lesueuri* had yellow spots in groin.

DISCUSSION

The surveys were conducted over six days and in that period 22 species of reptile and nine species of frog were detected. Additional surveys over different seasons would most likely reveal additional species.

The presence of several species of reptile represented extensions to their currently known range. The occurrence of the Gippsland Water Dragon was a northerly range extension for this subspecies of some 200 km (from the Shoalhaven River, see Swan, 1990). It would be interesting to survey the Abercrombie River to see if the subspecies *P. lesueurii lesueurii* is present or if intergrades exist. Male Water Dragons which are intermediate in colour between the subspecies have been observed at Jamberoo on the south coast of NSW (G. Daly pers. obs.). Other species which were detected outside their known distributions (see Swan, 1990) were the Nobbi Dragon, Tree Skink and Marbled Gecko.

Hand searching along transects detected nine of the 20 species of reptile recorded. The larger skinks and snakes were either caught in cage traps or detected opportunistically. This study indicated that several species were patchy in their distribution or had such low densities that they were not detected during systematic surveys. This highlights the need to employ a variety of survey methods in different habitats so that a larger number of species can be detected.

The most significant species found during the survey was the Booroolong Frog. The species is currently listed on Schedule 1 of the NSW Threatened Species Conservation Act (1995) as Endangered. This species has had a marked decline over the last twenty years and has virtually disappeared from the northern Tablelands (Anstis *et al.*, 1998; M. Mahony pers. comm.). The decline appears to be more severe in the north of the species historic range as surveys in southern NSW and northern Victoria found the species at 14 of 41 sites (Gillespie, 1999).

Sympatry between the Booroolong Frog and other members of the *Litoria lesueurii* complex has rarely been recorded. To date the areas where the species are known to be sympatric are Abercrombie Caves (this study and Anstis *et al.*, 1998) and Cox's River (J. Recsi, pers. comm.).

The dead and moribund frogs exhibited symptoms (as defined by Berger *et al.*, 1999) and were subsequently found to be infected by the frog chytrid fungus. The presence of amphibian chytrid fungus was a concern as the decline of several species of frog in Australia is linked to this disease (Berger *et al.*, 1999).

There is accumulating evidence, which indicates that the frog chytrid fungus is now widespread in a variety of habitats in eastern Australia (Berger *et al.*, 1999). The spread of the pathogen is greatly enhanced by frogs dying in creeks as water would facilitate the transfer of the aquatic zoospores while tadpoles would also be in contact with the fungus if they consumed dead frogs.

The presence of trout has implications for the survival of stream breeding species of frog in this catchment. Trout eat tadpoles and are implicated in the decline of several riverine breeding species of frog (Gillespie & Hero, 1999). Trout were introduced to the upper catchment of Grove Creek in 1988 (B. Cubitt pers. comm.). The persistence of the Booroolong Frog at Grove Creek may be a result of the creek frequently being reduced to isolated pools (B. Cubitt pers. comm.) and the population of trout being reduced as a consequence.

We recommend that a management plan be prepared for the Grove Creek population of Booroolong Frog. This plan should address the potential impacts of introduced fish, pathogens, weeds and nutrient loads in the creek. There should also be further surveys for the Booroolong Frog in other tributaries of the Abercrombie River and animals (tadpoles) taken for a captive breeding program.

Figure 1. Location of reserves.

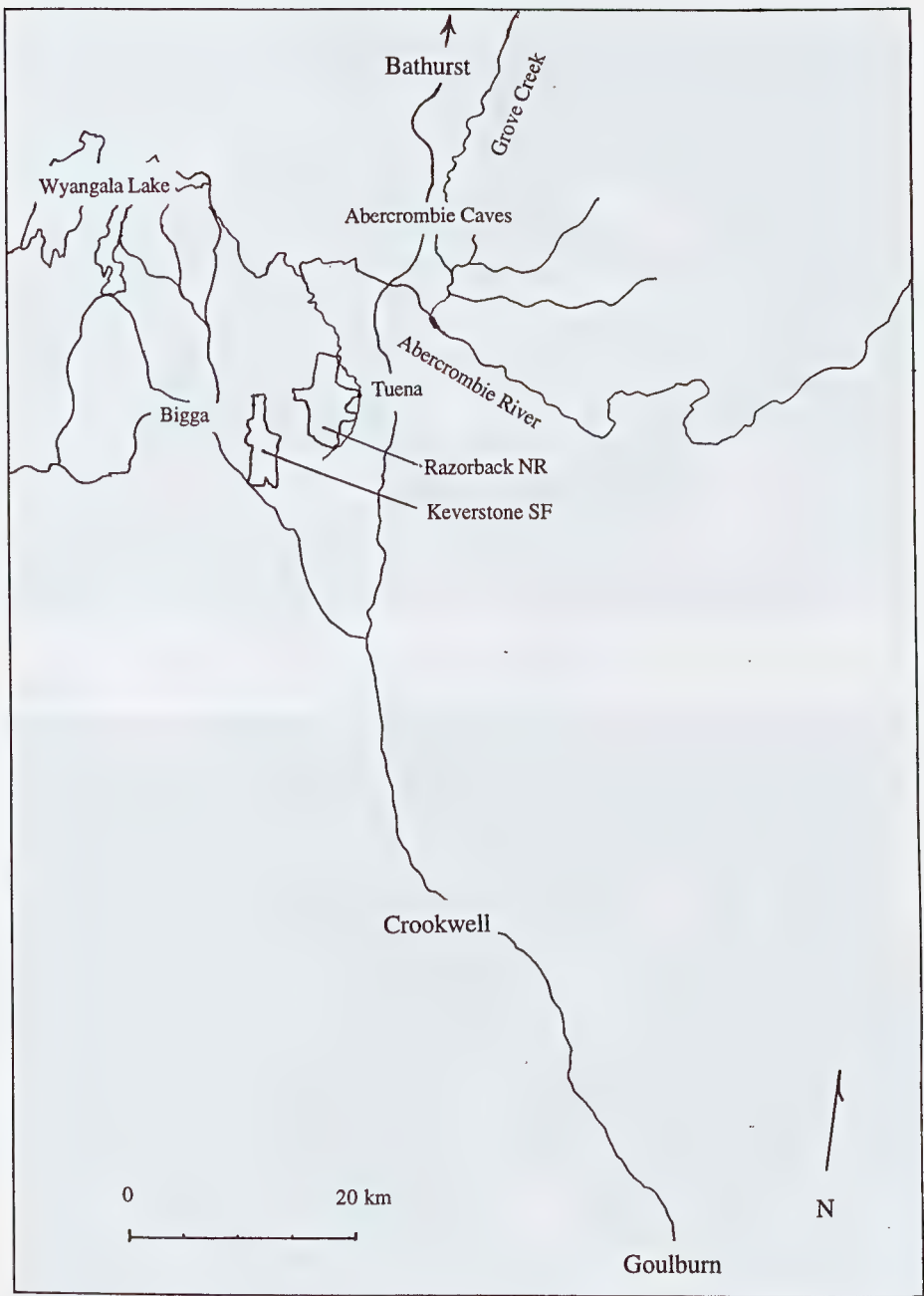


Figure 2. *Litoria* sp. affin. *lesueuri* from Abercrombie Caves. Photo: G.



Figure 3. *Litoria booroolongensis* from Abercrombie Caves. Photo: G. Daly



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SURVIVAL TECHNIQUE BY A SHORT TAILED PYGMY MONITOR *VARANUS BREVICAUDA* IN A FLOOD SITUATION.

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INTRODUCTION

The Short Tailed Pygmy Monitor (*Varanus brevicauda*) is the smallest monitor species in the world (Wilson & Knowles, 1988; Ehmann, 1992; Bennett, 1995; De Lisle, 1996). They occur throughout central Australia from the coast of Western Australia through to the interior of Northern Territory and north western South Australia to western Queensland. They occur in compacted sandy loam often associated with gravel, in areas dominated by spinifex (*Triodia* sp.). This terrestrial species is secretive, rarely seen active above ground and is mainly encountered by digging up burrows or more commonly through the use of pit traps (Pianka, 1994; James, 1996). Much of the published data on the ecology of this species is based on museum specimens and from pit trapped animals in the field (Pianka, 1994; James, 1996). The following observation was made at 10.15 am on 24 March 2000 approximately 50 km north of the Minilya Roadhouse in Western Australia. This was towards the end of the summer wet season and three weeks prior to this observation this part of the coast of Western Australia was hit hard by Cyclone Steve.

OBSERVATION

Whilst stopped on the road next to a flooded water crossing, I noticed a small animal in the water. Closer inspection confirmed that it was a small monitor in the slow moving current. On first appearance the posture of this specimen led me to believe that it was actually drowned, half-floating. However, while leaning out over the animal and with out disturbing the water I realized that it was in fact very much alive. The eyes were closed and

the front legs were tucked in straight down beside the body. The tail and hind legs were still in a burrow in the ground. Its entire body was under water except for the snout and nostrils, which were just breaking the water surface. To reach oxygen it was stretched straight up as far as it could with its belly surface leaning slightly into the current.

DISCUSSION

During floods it is not uncommon to see reptiles on the move heading for higher ground before retreat sites go under water or having already been washed out of their refuge. Many terrestrial reptiles are adept swimmers (Jackson, pers. obs.) yet they would struggle in rapids of water caused by the more severe floods. During the above observation the rain had begun around 8.00pm the night before and rained heavy until around 4.00 am in the morning. There was already a lot of water around due to all the previous rain. I believe that this specimen of *V. brevicauda* more than likely spent the night submerged. By the time the observation was made the sun had been out for a few hours. The presence of the sun may have drawn the monitor to the surface of the water for air during what is their normal active time of day. Whilst the need for oxygen required the lizard to surface despite the presence of a water current, it anchored itself to its burrow rather than opting to swim to a shrub or dry ground. When reaching down and grabbing the monitor for closer inspection it immediately tried to pull itself back down into its burrow, exemplifying its ability to retreat into its flooded burrow if required. Leaving the burrow for higher ground could have left the monitor exposed to predation for a prolonged period until

alternative shelter could be located thus resulting in the development of this unique defense strategy.

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OBSERVATIONS OF THE FORAGING BEHAVIOUR OF ADULT GREEN AND GOLDEN BELL FROGS (*LITORIA AUREA*).

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It has been widely asserted that adult Green and Golden Bell Frogs (*Litoria aurea*) feed on a wide variety of terrestrial invertebrates and on smaller individuals of the same species (Krefft, 1863; Fletcher, 1889; Lucas & Le Souef, 1909; Copland, 1957; McCann, 1961; Barker & Grigg, 1977; Dankers, 1977; Humphries, 1979; Hoser, 1989; Hero *et al.*, 1991; Cogger, 1992). There are however, no published observations of the foraging behaviour of this species (Pyke & White, 2001).

This present note reports on observations of the foraging behaviour of adult *L. aurea* that were made during a study of the diet of this species on Broughton Island, New South Wales (Miehs, 2000). This study forms part of a larger program of research on the population biology of this frog species on Broughton Island (Pyke, 1999).

Broughton Island is approximately 114 hectares in area and is located 3 – 5 km off the coast of Central New South Wales, near Hawks Nest (latitude: 32° 37' S; longitude: 152° 19' E). Two frog species, *L. aurea* and *Limnodynastes peronii*, are found in a number of small ponds, mostly located around the rocky perimeter of the island.

Observations were made opportunistically both during the day and at night. Periods of up to two hours were spent watching the water bodies from a distance of about two metres from the edge, with minimal observer motion. Night-time observations were made with the aid of a headlamp that was covered with red cellophane. The observations reported here were made between October 1999 and February 2000.

Observations were made at two different sites. One was an artificial well measuring 3 m by 4 m in cross-section and approximately 24 cm deep at the time of observation. This well contained filamentous algae but no emergent vegetation. Observations here were made at night. The other was a natural pond that was roughly triangular in shape, with side lengths of about 7, 8 and 10 m, and had a maximum depth of about 50 cm at the time. There were about 3–4 square metres of open water containing some filamentous algae at the deeper end of this pond. Observations here were made during the day-time.

Both frog species have been detected at each of these sites, but very different age/size classes and numbers of individuals have been found at the two sites (Pyke & White unpubl. obs.). At the pond, large numbers of *L. aurea* tadpoles, metamorphs (i.e. individuals with well-developed front and hind limbs and still retaining a noticeable tail), immature frogs (i.e., 4 cm or less in snout-vent length) and adult frogs (i.e., more than 5 cm in snout-vent length) have been observed. At this pond, however, relatively few tadpoles, metamorphs and adult frogs of *L. peronii*, and no immature frogs of this species, have so far been observed. At the well, relatively few adult *L. aurea* and no tadpoles, metamorphs or immature frogs of this species have been observed. At this site *L. peronii* outnumbered *L. aurea*, with all life-history stages of the former having been encountered.

During night-time observations at the well on 26 January 2000, adult *L. aurea* were observed catching and eating *L. peronii* tadpoles. At least eight *L. aurea* were seen floating on the top of the water. As tadpoles swam

up to the surface for air, *L. aurea* would orientate towards them (with a small amount of one-sided leg-paddling) and then dive in head-first towards them. One adult *L. aurea* was observed surfacing from the water with a tadpole's tail hanging out of its mouth. It then used its right hand to push the rest of the tadpole in its mouth. Only *L. peronii* tadpoles were present in the well.

During daytime observations at the pond over three days (29 November – 2 December 1999), adult *L. aurea* were observed catching and eating metamorphs of the same species. On seven occasions the following stages were witnessed, with both adults and metamorphs resting on and walking across an algal mat that was floating on the surface of the water. An adult *L. aurea* would first look towards a metamorph, then flatten its body and slowly move towards the metamorph, often taking a couple of steps forward and then pausing for a few minutes before continuing the stalking process. During this process, which sometimes lasted for over 30 minutes, the adult's gaze was apparently fixed on the metamorph as it did not look in any other direction. Once the adult had moved to within about 20 cm from the metamorph, it lunged at it. These lunges resulted in successful prey capture on four of the seven occasions. On the other three occasions the metamorph jumped out of the way or dived under water, and was missed by the adult.

These observations and the frequently-heard distress calls of immatures suggest that such predation on metamorphs may occur quite frequently at times of the year when metamorphs are abundant. On one of the above-mentioned occasions, an adult jumped at a metamorph, caught it by the legs, and then took approximately six minutes to restrain and swallow it. During this process the metamorph struggled and emitted a "distress call". This same call has been heard at many other times, both during the day and at night. Metamorphs have only been recorded vocalising during this study when captured by *L. aurea* or by the eastern water skink, *Eulam-*

prus quoyii (Pyke & Miehs, 2001). This suggests that many of the vocalisations were caused by *L. aurea* predating on the metamorphs.

A dietary study based on stomach-flushing of adult *L. aurea* supports this suggestion, and indicates firstly that tadpoles and metamorphs may constitute a significant part of an adult's diet, and secondly that *L. aurea* will feed on members of either its own or other frog species (Miehs, 2000). For the sample of adult *L. aurea* that were captured at the well from November 1999 – March 2000 and that did not have empty stomachs, 18.8% ($n = 31$) were found to contain *L. peronii* tadpoles or metamorphs in their stomach (Miehs, 2000). For a sample of adult *L. aurea* captured in the vicinity of the pond at this time, 22.2% ($n = 40$) of non-empty stomachs contained tadpoles or metamorphs (Miehs, 2000).

These observations indicate that adult *L. aurea* on Broughton Island forage both during the day and at night, that they are able to forage in water, that they are partly cannibalistic in food habits, and that tadpoles and metamorphs of their own or other species may form major components of their diet. While preying on tadpoles they essentially adopted a "float-and-wait" strategy, whereas they actively "stalked" metamorphs as prey. In both cases there was a rapid lunge toward the prey when it was within range. Further studies should be conducted to determine the extent to which mainland populations exhibit the same behaviours.

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OBSERVATIONS OF UNUSUAL *ADELOTUS* IN THE CARNARVON RANGES, QUEENSLAND.

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Between 5-10 October 1997, I spent several days at Carnarvon National Park, which is situated approximately 600km north west of Brisbane in the Carnarvon Ranges. The weather had been fairly dry, the days were warm and nights mild. I went spotlighting every night I was there and several species of frogs were observed along a 2 km stretch of Carnarvon Creek upstream from the camping ground.

One night, I heard a call that I could not identify. It was a sort of rattly three part note that sounded something like *Limnodynastes tasmaniensis*. It was coming from beneath a small pile of rounded stones in the middle of a still backwater of the main stream. I identified the stone which it appeared to be coming from and gently lifted it. Sitting beneath it, half submerged, was a small brownish frog (Figs. 1-2). The frog was clearly *Adelotus*, and not *L. tasmaniensis*, but the call was different to that which I was familiar with in New South Wales populations of *Adelotus brevis*. It also lacked the red coloration on the backs of the legs and groin region which is typical of *Adelotus brevis* in New South Wales, and the ventral coloration was not densely variegated with black on white as previously illustrated and described for this species (Cogger, 2000; Barker *et al.*, 1995). These observations raise several possibilities: was it a unique one off, or is there perhaps a subspecies or species unique to the area? Although the individual reported here was not collected, *Adelotus* has previously been reported from Carnarvon Gorge, on the basis of a specimen (J16269, collected in 1962) in the Queensland Museum (Ingram and Longmore, 1991; P. Couper, pers. comm.). Further work on this population is warranted to determine whether

the colour pattern differences are consistent, and whether the call heard represented the normal advertisement call of this population rather than a male-male interaction call.

The Carnarvon Ranges also have disjunct populations of several reptile species, including *Notechis scutatus*, *Calypotis scutirostrum*, *Egernia cunninghami* and *Lampropholis adonis* (Covacevich and Couper, 1991; P. Couper, pers. comm.).

Other frogs species I observed in the area were *Limnodynastes ornatus*, *Limnodynastes peronii*, *Litoria caerulea*, *Litoria lesueurii* and *Litoria latopalmata*. Male *Litoria lesueurii* were present in huge numbers. At any given point along the creek, dozens of pairs of eyes could be seen. It wasn't uncommon to see two or three individuals on one small rounded stone at the water's edge. Despite the huge numbers of males observed, I only saw two females and they were several metres back from the stream. No males were calling, although they were in breeding colours. This was my third visit to Carnarvon National Park, the last being in 1985. There were no Cane Toads (*Bufo marinus*) present then. However, this time they were common.

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Figures 1. Dorsolateral view of *Adelotus* from the Carnarvon Ranges.

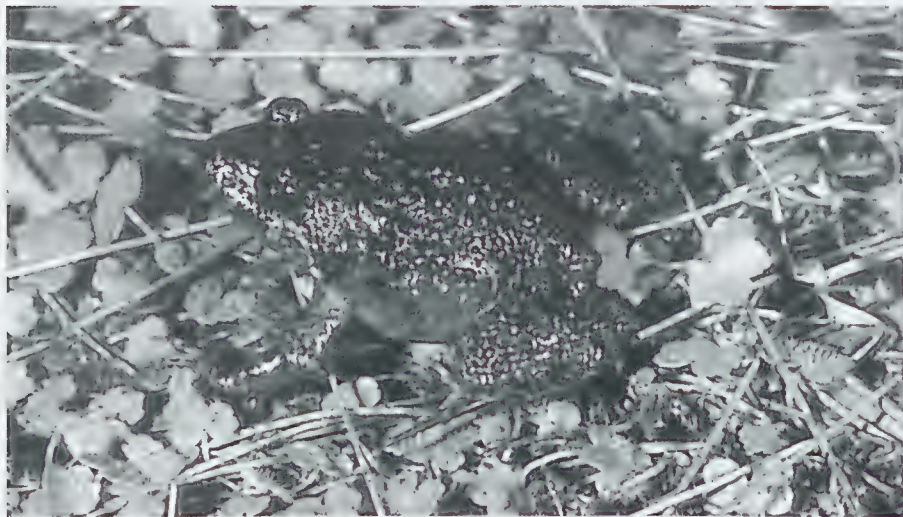
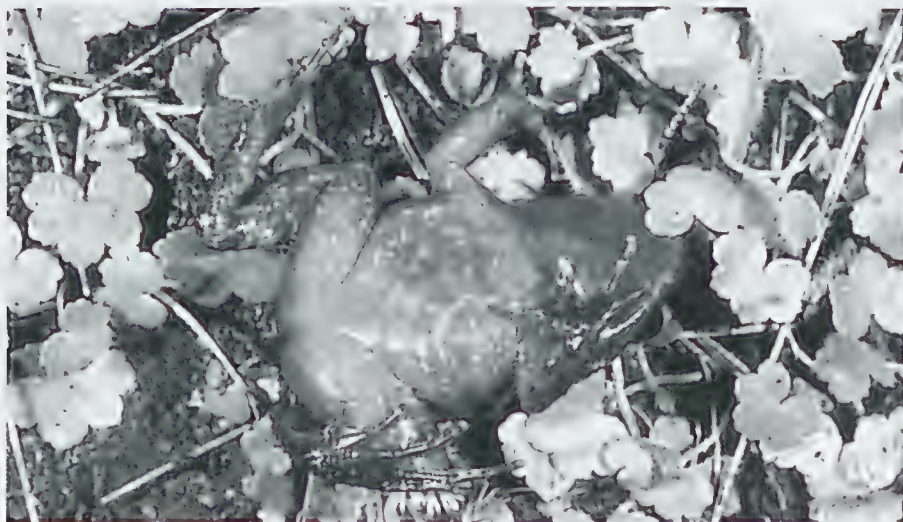


Figure 2. Ventral view of *Adelotus* from the Carnarvon Ranges.



PREDATION BY WATER SKINKS (*EULAMPRUS QUOYII*) ON TADPOLES AND METAMORPHS OF THE GREEN AND GOLDEN BELL FROG (*LITORIA AUREA*).

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Many different kinds of animals have been listed as likely or known predators of tadpoles or frogs of the Green and Golden Bell Frog *Litoria aurea*. For tadpoles these include birds, reptiles such as the Long-necked Tortoise (*Chelodina longicollis*) and Red-bellied Black Snake (*Pseudechis porphyriacus*), fish, both native and introduced, and various aquatic invertebrates (Bell, 1982; Morgan, 1995; Morgan & Buttemer, 1996; Hamer, 1998; Pyke & White, 1996, 2000, 2001). Known or likely predators of frogs of this species include birds, snakes, the introduced Black Rat (*Rattus rattus*) and Red Fox (*Vulpes vulpes*), Brown Mantis (*Archimantis latistyla*), and larger *Litoria aurea* (Krefft, 1863; Tyler, 1976; Daly, 1995; Hamer, 1998; Pyke & White, 2001; J. Cann, pers. comm).

However, despite these long lists of potential predators of *L. aurea*, there are neither published descriptions of predation on the species nor assessments of the relative importance of different kinds of predation. There are also no published reports of lizard predation on *L. aurea*.

The Water Skink (*Eulamprus quoyii*) feeds mostly on diurnal terrestrial insects, though it will also feed on small lizards and aquatic invertebrates such as water beetles (Family: Dysticidae) and damselfly larvae (Order: Odonata) (Veron, 1969; Daniels, 1987; Schwarzkopf, 1996). It has also been observed feeding on tadpoles in captivity (*Litoria rubella*, *Limnodynastes dumerili*, *L. tasmaniensis*, *Crinia signifera*; Daniels, 1987). When feeding on tadpoles and aquatic invertebrates, it foraged by sitting at the water's edge, waiting until they surfaced within range and then lunging at them

(Daniels, 1987). Although the water skink will dive underwater to avoid predators (Veron and Heatwole, 1970), it does not appear that it does so to capture prey (Daniels, 1987). There is a single record of a frog in the stomach contents of *E. quoyii* (species not reported; Daniels, 1987). Given the opportunity, *E. quoyii* would therefore be a potential predator of tadpoles, metamorphs (i.e., individuals with well developed front and hind limbs and a tail) and small immature frogs of *L. aurea* that are either on the ground or within reach from the water's edge. Adult *L. aurea*, which are typically more than 5cm in snout-vent length, would be undoubtedly too large to fall prey to these skinks that are typically only about 10 cm in snout-vent length (Cogger, 2000).

Herein we report observations of *E. quoyii* catching and feeding on both tadpoles and metamorphs of *L. aurea*. Observations were made during October 1999 and March 2000 on Broughton Island, a 114 ha island located 3-5 km off the central coast of New South Wales near Hawks Nest (32° 37' S; 152° 19' E). Two frog species (*Litoria aurea* and *Limnodynastes peronii*), one snake species (*Hemiaspis signata*) and seven lizard species (*Pygopus lepidopodus*, *Ctenotus robustus*, *Ctenotus taeniolatus*, *Lampropholis guichenoti*, *Lampropholis delicata*, *Saproscincus mustelinus* and *Eulamprus quoyii*) have been recorded on this island (Pyke, 1999; A. White, pers. comm.).

Observations were made at several small ponds that were near the northeast edge of the island and only about 20m from the ocean. During times when tadpoles and metamorphs were present in these ponds,

Eulamprus quoyii was always present and conspicuous around the edges of the ponds. Occasionally observations were made as a pond was approached or during the course of other research activities. But in most cases, observations were made during breaks from these activities when a pond could be watched continuously by an observer from a distance of about 2m for up to about 2 hours. It was found that frogs and lizards were initially disturbed by an approaching observer, quickly retreating or moving out of sight, but that if the observer remained reasonably motionless for about 10-15 minutes these animals would return and thereafter move about with apparent disregard for the observer. It was during these times that the observations reported here were made.

Water skinks were observed feeding on tadpoles at two ponds that differed markedly in terms of water level. The first set of observations was made at a pond that was filled with water (maximum depth about 50 cm) and in which *L. aurea* tadpoles frequently surfaced for air. The skinks would hide behind rocks and in crevices near the water's edge and lunge at tadpoles when they surfaced within about 10 cm. Two of four skinks employing this strategy were successful, catching what appeared to be relatively large tadpoles. The second set of observations was made at a pond that was drying up, had a maximum depth of only about five cm and contained a very high density of *L. aurea* tadpoles that gave the appearance of a writhing mass. The skinks either waited in vegetation at the water's edge or moved out into the middle of the pond. In both positions the skinks would stare at the water and then lunge in the direction of the tadpoles. One skink, employing this strategy, consumed at least 25 relatively small tadpoles (less than 2 cm in total length) in about as many attempts during eight minutes of observation.

Whenever such ponds have been observed, one to three skinks have generally been seen in the vicinity, along with high densities of skink tracks in the soft sand or soil next to the

water. These observations suggest that as ponds containing tadpoles dry out the level of skink predation on tadpoles may be high.

Water skinks were also observed catching and eating metamorphs at one pond. In this case the pond was full of water (maximum depth about 50 cm) and at least 50 metamorphs were basking on aquatic macrophytes. On about 10-15 occasions, skinks were observed to swim slowly towards a metamorph (with only its head visible) and to lunge when they got within about 30 cm. On two of these occasions the skink was successful.

One skink (that judging on its size was an immature) seemed noticeably inept at catching *L. aurea* metamorphs. It slowly stalked and unsuccessfully lunged at a metamorph before it changed its strategy and quickly (without any preliminary stalking) charged at about 15 metamorphs scattered around the pond. It took 16 minutes and over five attempts before it finally captured a metamorph.

Ingestion time for *E. quoyii* when its prey was a metamorph was much greater than when the prey were relatively small tadpoles. Water skinks observed feeding on small *L. aurea* tadpoles were able to swallow each tadpole in two seconds or less (approximately 50 observations), while it took a water skink over two minutes to swallow a *L. aurea* metamorph. This difference may reflect differences in prey-size as metamorphs on Broughton Island are generally about 23-33 mm in snout-vent length and have four protruding limbs, whereas the tadpoles were only about 10-18 mm in snout-vent length with a relatively flexible tail (Pyke, unpublished).

It is possible that predation by *E. quoyii* may be a significant source of daytime mortality of *L. aurea* tadpoles and metamorphs on Broughton Island. They were always observed around ponds when *L. aurea* metamorphs and/or tadpoles were present and, on the few occasions when we took time to observe them closely, they were catching and eating either

tadpoles or metamorphs of *L. aurea*. This warrants further investigation.

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MITE INFESTATIONS IN AUSTRALIAN SKINKS: SEASONAL, GEOGRAPHICAL AND ECOLOGICAL VARIATION.

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ABSTRACT

Lizards often have aggregations of the larvae of trombiculid mites in their axillae ("armpits"). In some lizards, these axillae are invaginated and are referred to as mite pockets. There has been substantial debate on the evolution and adaptive significance of mite pockets. However, very little work has been done on the basic patterns in mite occurrence, such as geographical, seasonal and size variations. I recorded mite numbers in the axillae of six species from three genera of Australian skinks (*Carlia*, *Cryptoblepharus* and *Ctenotus*). In tropical species that experience warm, moist conditions during summer, mite larvae were more abundant in summer than in winter. In *Carlia vivax*, larger lizards had more mites ($R^2 = 0.10$, $P = 0.04$, $n = 41$), but this was not the case in the other species I examined. Mite numbers overall were similar in left-hand-side versus right-hand-side axillae, but species differed significantly in this respect. The functional significance of this species-specific asymmetry remains unclear. There was no difference in mite-load between males and females during summer in the one species examined for this aspect, *Carlia gracilis*.

INTRODUCTION

The axillary regions of lizards often have aggregations of the larvae of trombiculid mites. The larval stage is the only parasitic one of the four developmental stages: egg, larva, nymph and adult (Sasa, 1961). The common name for members of the mite family Trombiculidae is chigger (Sasa, 1961).

In some lizards, the axillary regions have evolved to form invaginations called mite pockets (Arnold, 1986). Invaginations also occur in other protected areas of lizards, such

as the sides of the neck, groin and post-femoral region (Arnold, 1986). These sites have a good blood supply, and the larvae attach themselves to the host at these points, feeding on cellular debris and tissue fluid (Arnold, 1986). Once the larvae are engorged, they drop off and return to the soil to complete maturation (Sasa, 1961).

There are two alternative hypotheses about why mite pockets have evolved in lizards. Arnold (1986) suggested that the pockets have evolved as adaptations to ameliorate damage caused by the parasites, by concentrating the larvae in one place. In contrast, Bauer *et al.* (1990) argued that mite pockets have evolved as a result of unknown selective forces, and are facultatively exploited by the larvae of mites with no evidence to suggest that pockets ameliorate the damage caused.

Subsequent studies on mite pockets have mostly supported the hypothesis put forward by Arnold (1986). Goldberg and Holshuh (1992) found that increased exposure to mite infestations caused increasingly severe reactions in the mite pockets of the iguanid *Sceloporus jarrovi* (Yarrow's Spiny Lizard). By concentrating them in the pockets, the damage caused to the lizard is localised (Goldberg & Holshuh, 1992). This evidence supports the ectoparasite damage limitation hypothesis put forward by Arnold (1986).

Salvador *et al.* (1999) attempted to determine whether pockets reduce the damage caused by ectoparasites. The work was done in relation to ticks rather than mites, but the results are relevant here. The experimental study was carried out on the lacertid *Psammodromus algirus*, which has nuchal pockets. Salvador *et al.* (1999) found that when parasite loads are low, the pockets are beneficial by concentrating the parasites in areas where

interference with functions related to fitness are reduced. However, heavier loads resulted in infestations in other areas, such as the ears. Lizards with heavy loads and nuchal pockets blocked experimentally had reduced home ranges (restricted movement patterns) and were seen over a shorter period of time (interpreted as being due to higher mortality). These data militate against Bauer *et al.* (1990)'s argument that pockets are not beneficial to lizards. However, it is possible that the experimental blockage of nuchal pockets using glue may have caused the reduction in home ranges.

Goldberg and Bursey (1993) studied the duration of attachment of mites in *Sceloporus jarrovi*. The duration was highly variable, although mites may remain attached in mite pockets for longer periods of time than elsewhere.

Much of the work done on mite pockets has focussed on their evolution and adaptive significance. However, little work has been carried out on basic patterns in mite occur-

rence, such as geographical, seasonal and size variations. No definitive work is available on the presence or absence of sex differences in mite-load, although Salvador *et al.* (1999) observed that during the mating season, males were more frequently infested with ticks than were females and juveniles.

My study was on mites in the axillary regions of lizard species in the family Scincidae, a reptile lineage on which very little work has been done in this respect. Arnold (1986) examined potential hosts from several sites in northern Queensland. He found that the great majority of skinks carrying mites were from the genus *Carlia*, and these mites were found in the axillary region.

My research was aimed at broadening the knowledge of mite infestations in the axillary regions of lizards, and particularly in Australian skinks. Susceptibility of skinks to mites in different habitats, seasonal variation in mite infestation rates and the relationship between snout-vent length and mite-load was investigated. The possibility of a correlation

Table 1: Habitat and distribution of animals examined for each species studied. (Qld = Queensland; NSW = New South Wales; NT = Northern Territory). Data from Cogger (2000).

Species	Distribution of animals examined	Habit	Habitat
<i>Carlia tetradactyla</i>	Eastern Australia, specimens examined from the western slopes of NSW	Ground dweller	Dry sclerophyll forest
<i>Carlia vivax</i>	Along Qld coast overlapping into northern NSW	Ground dweller	Seasonally dry open sclerophyll forest and tall woodland
<i>Carlia gracilis</i>	Northern part of NT	Ground dweller	Seasonally dry open sclerophyll forests
<i>Ctenotus essingtoni</i>	North coast of NT and Qld	Ground dweller	Seasonally dry tropical woodlands and coastal dunes and shrublands
<i>Carlia rubrigularis</i>	Rainforests of north-eastern Qld	Ground dweller	Openings in rainforest
<i>Cryptoblepharus plagiocephalus</i>	Virtually Australia wide, except for east and south-east (only specimens from the NT examined)	Primarily arboreal	Tropical to temperate woodlands

between mite-load and sex of the animal within the season of greatest infestation was also considered.

MATERIALS AND METHODS

Four species of *Carlia* (*C. gracilis*, *C. rubrigularis*, *C. tetradactyla* and *C. vivax*), one species of *Ctenotus* (*C. essingtoni*) and one species of *Cryptoblepharus* (*C. plagiocephalus*) were chosen for the study. Preserved specimens were obtained from the Australian Museum. The species were chosen on the basis of their different distributions and habitats (Cogger, 2000 and Table 1).

General inspection showed that mites were concentrated in the axillae, only occurring on other parts of the body, such as ears and eyes, when infestation levels (number of mites) were very high. For all six species, each specimen was examined for mites, and total numbers were recorded in both the left and right axillary regions. The snout-vent length (SVL) was recorded for animals with mites. The total number of specimens of each species examined was noted, and the dates of collection were recorded for each specimen. Dates were converted into Julian dates (numbers from one to 365) and divided into winter and summer. April 16th to October 15th was defined as winter and October 16th to April 15th was defined as summer. While the different species may experience different lengths of seasons, the overall patterns are covered within each six month period.

Carlia gracilis was examined in greater detail due to the larger sample size and time restrictions. The SVL was recorded for all specimens, both with and without mites, and the sex of each animal with mites was also recorded.

A Pearson's Chi-Squared (χ^2) test was used to determine whether there was a significant association between the presence or absence of mites and season. A least squares regression analysis was carried out to determine whether there was a significant correlation between SVL and total mite-load (total

number of mites). A sign test was carried out to find out whether there was a significant level of asymmetry in mite infestation between the left and right axillary regions for animals with mites. A two-sample t-test was carried out within the season of greatest infestation to determine whether there was a significant difference in the total mite-load between males and females within this season.

RESULTS

Seasonal variation in mite-load

There was a significant seasonal variation in frequency of mite infestation in three of the species examined: *Carlia vivax*, *C. gracilis* and *Ctenotus essingtoni*. There was a significantly greater proportion of lizards infested with mites in summer than in winter (Table 2). Results for two other species, *C. rubrigularis* and *Cryptoblepharus plagiocephalus*, came close to being significant. *Carlia tetradactyla*, on the other hand, showed no significant seasonal variation. However, as only two specimens had mites in their axillae (see Table 2), significant differences could not be detected.

Correlation between mite-load and SVL

Carlia vivax showed a significant positive correlation between mite-load and SVL ($R^2 = 0.10$, $P = 0.04$, $n = 41$). *Carlia gracilis* ($R^2 = 0.07$, $P = 0.07$, $n = 51$) (Fig. 1) and *Ctenotus essingtoni* ($R^2 = 0.10$, $P = 0.14$, $n = 24$) came close to showing a significant correlation. However, *C. rubrigularis* ($R^2 = 0.06$, $P = 0.23$, $n = 28$) and *Cryptoblepharus plagiocephalus* ($R^2 = 0.04$, $P = 0.36$, $n = 23$) showed no significant correlation between mite-load and SVL. Most animals have few mites, but some individuals have large numbers (Fig. 1).

Difference between mites in left and right axilla

There was no significant difference between the number of mites in the left and right axillae of individual species: *C. vivax* ($P = 0.10$, $n = 37$), *C. rubrigularis* ($P = 0.45$, $n = 7$), *Carlia gracilis* ($P = 0.88$, $n = 42$), *Cryp-*

tolepharus plagiocephalus ($P = 1.0$, $n = 19$) or *Ctenotus essingtoni* ($P = 0.79$, $n = 14$). There were insufficient data to carry out the test for *C. tetradactyla*.

Variation in mite-load with sex

Mite-loads (number of mites per animal) in *Carlia gracilis* did not vary significantly between males and females in the season of greatest infestation, summer ($t = -0.60$, $P = 0.56$, $n = 22$).

DISCUSSION

Seasonal variation in mite-load

There was an association between mite-load and season for *Carlia vivax*, *C. gracilis* and *Ctenotus essingtoni*, but not for the other taxa examined. This interspecific difference may be due to the different distributions and habitats of the species, as suggested by Arnold (1986) and Zippel *et al.* (1996): mites are most likely to be found in warm, moist environments. *Carlia vivax* and *C. gracilis* live on the ground in seasonally dry open sclerophyll forests with a grass understorey and *C. essingtoni* lives on the ground in seasonally dry tropical woodlands. All these habitats are dry during the winter when there is a reduced amount of rainfall and temperatures are cooler. However, during summer, they are warm and moist, creating a favourable environment for mite development and maturation (Sasa, 1961).

There was no significant seasonal variation in *Carlia rubrigularis* and *Cryptoblepharus plagiocephalus*, although both show a tendency towards summer as the season of greatest mite infestation. There are several plausible explanations for the lack of a significant seasonal variation: *Carlia rubrigularis* lives in rainforests, while *C. plagiocephalus* lives in tropical to temperate woodlands. Unengorged larvae tend to conceal themselves in shaded areas (Sasa, 1961), which may be plentiful in these habitats, reducing mite densities and the chance that a lizard will pick them up. It may also be possible that this group of mites is less suited to rainforests (not

addressed in literature), and thus the low levels of infestations during both seasons. Alternatively, it may be because conditions are more uniform through out the year in rainforests and tropical areas, resulting in aseasonality. In addition, *C. plagiocephalus* is more arboreal than the other species examined, spending less time on the ground, making them less vulnerable. While there are plenty of crevices in trees, wind can get into them, drying them out, and the mites are probably terrestrial, although there is no definitive evidence for this.

Carlia tetradactyla on the other hand is a southern species from the Sydney region. In this area, the temperature is often cool in winter and hot and dry in summer, perhaps creating a poor environment for mites. In summer, only two specimens out of 86 had mites resulting in a very low frequency of infestation (0.023). By comparison, all other species examined are distributed further north, from northern NSW to Qld and the NT, where the summers are warm and moist.

Seasonality in mite-load appears to be due to the biology of the mites themselves. Most trombiculid mites exhibit exceptional seasonal fluctuation, especially of the larval stages (Sasa, 1961). Warm and moist conditions are optimal for development and maturation of mite larvae (Sasa, 1961). Mite infestations are therefore most likely to occur when the environment is suitably warm and moist, that is, during summer in northern Australia.

Correlation between mite-load and SVL

Goldberg and Holshuh (1992) observed that all age groups (and therefore size groups) of *Sceloporus jarrovi* were infected with mites but did not test for a correlation between mite-load and SVL. *Carlia vivax* showed a significant correlation between mite-load and SVL ($P = 0.04$), however, the model explains very little of the variation ($R^2 = 0.10$). Similarly, in *C. gracilis*, where the P-value ($P = 0.07$) approaches significance, the model explains very little of the variation ($R^2 = 0.07$).

The low coefficients of determination may possibly be due to the random attachment of mites to a host, regardless of size of the individual and therefore the size of the axillary area available to mites (Fig. 1). For example, one female, summer-caught specimen of *Carlia gracilis* had a SVL of 39.5mm with just one mite. By contrast, a second female, summer-caught specimen of *C. gracilis* had a SVL of 35mm with a total mite-load of 47. Another feasible explanation is that the variation is due to shedding; individuals with few mites may have recently shed while those with many mites may be about to shed (G. Shea, pers. comm.).

Difference between mites in left and right axilla

Individual species did not deviate significantly from 50:50 in left and right axillae. Similarly, no asymmetry was found between the left and right axillae in the Yarrow's Spiny Lizard, *Sceloporus jarrovi* (Goldburg & Bursey, 1993).

Variation in mite-load with sex

According to Salvador *et al.* (1999), males were more frequently infested during the mating season than were females and juveniles. This difference was attributed to higher concentrations of testosterone in males during this time. However, frequencies of infestation were not quantified. In addition, the difference may have been due to the greater activity levels in breeding males seeking out females, resulting in more frequent encounters with mites. I did not find any significant difference in mite-load during summer (the season of greatest infestation) between males and females in the species *Carlia gracilis*.

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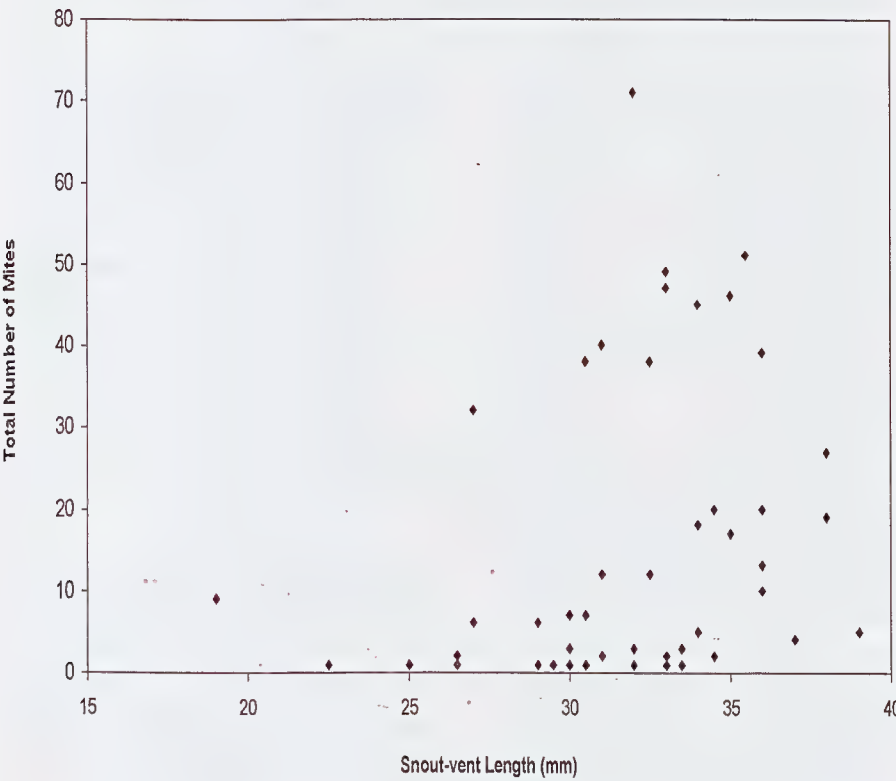
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Table 2: Seasonal variations of mite infestations in different scincid species.

Species	Number of animals with mites (Proportion of total)		x ²	P-value
	Winter	Summer		
<i>Carlia tetradactyla</i>	0/72 (0.000)	2/86 (0.023)	1.70	0.20
<i>C. vivax</i>	6/141 (0.043)	28/97 (0.289)	28.43	0.00
<i>Ctenotus essingtoni</i>	6/76 (0.079)	14/19 (0.737)	39.58	0.00
<i>C. gracilis</i>	27/209 (0.129)	16/27 (0.593)	34.46	0.00
<i>C. rubrigularis</i>	17/179 (0.095)	10/57 (0.175)	2.76	0.10
<i>Cryptoblepharus plagiocephalus</i>	15/166 (0.090)	6/33 (0.182)	2.44	0.12

Figure 1: Relationship between total number of mites and snout-vent length in *Carlia gracilis*.



A NOVEL NESTING HABITAT FOR KREFFT'S TURTLE (*EMYDURA KREFFTII*).

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Seven species of freshwater turtle in the southeastern United States are known to oviposit in American alligator (*Alligator mississippiensis*) nest mounds (Carr, 1952; Goodwin & Marion, 1977; Dietz & Jackson, 1979; Kushlan & Kushlan, 1980; Hunt & Ogden, 1991). This behaviour occurs more frequently when high water levels limit the availability of alternative nesting sites (Enge *et al.*, 2000). The turtles respond to variations in a local nesting environment by adaptive choice of nesting site. However, it is unclear whether the strategic use of elevated mounds of nesting substrate still applies to situations where turtles face natural or artificial alterations in the aquatic environment.

Herein we report a novel nesting substrate used by Krefft's turtle, *Emydura krefftii*, that appeared to be qualitatively similar to the well-documented descriptions of turtle eggs found in alligator nests. The finding is notable since there are only a handful of unpublished accounts on Australian turtles nesting within crocodile (*Crocodylus porosus*) nest mounds.

The observation was recorded during a regional survey of turtle biodiversity conducted by the Queensland Parks and Wildlife Service during 1997-1999. Within the Burnett River catchment, we surveyed Joe Sippel Weir on 5 November 1999, using the standard method of setting baited traps from a small boat. Located at 172 km upstream on Barimabah Creek, Joe Sippel Weir (26°16.314' S, 152° 00.343' E, base elevation at 295 m) has a 730 ML capacity and impounds the creek upstream for 10.2 km when at full storage level. The bordering fields and floodplain are in cotton production.

Most exposed substrates that are potential turtle nesting habitat within and outside of the floodplain are now well vegetated except for small patches of recently deposited alluvium, particularly on the inner bends of the river contours.

During the survey, we found dozens of hay bales that had been previously swept into the weir lake from nearby paddocks in flood. The semi-submersed bales were comprised of rolled pasture grasses and were similar in size (1.5 m diameter, 1.2 m tall) and structure to crocodilian nest mounds. There are no firm dates for when the bales became submersed (1-3 months minimum, judging from peak water flow: Queensland Dept. Water Resources, unpubl. data), but the hay was composting or rotten, even though bales remained intact from their surrounding nylon net. Not all of the bales were inspected individually because of priority time commitments to the trapping. However, for two bales that were inspected closely, each had an obvious excavated depression at the bale's center (Fig. 1). Careful probing of the depressions uncovered two clutches of intact turtle eggs from within each bale (Fig. 2). The clutches were situated approximately 20-30 cm above the waterline.

We took no eggs to conclusively confirm the species identity, but there are few reservations that the eggs were not those of *Emydura krefftii*. First, spring nesting limits the putative species in the Burnett River to only *E. krefftii*, *Elseya latisternum* and *Chelodina longicollis* (Legler & Georges, 1993). Second, the egg shapes and dimensions more closely matched measurements given for *E. krefftii* eggs, rather than the other two species (see

Legler & Georges, 1993). Third, *E. krefftii* constitutes 98.2% (3131/3189) of the turtle species collected within dams on the Burnett River (Tucker, 2000). All eggs had initiated a viable incubation as indicated by a chalky white zone around the middle of each egg. Clutch sizes were within the range recorded for *E. krefftii* in the Burnett River (Georges, 1985).

The use of an atypical nesting substrate after conditions of recent flooding suggests an adaptive strategy in nest placement. Australian chelids choose nesting habitats that are characteristically exposed to full sunlight during the day (Goode & Russell, 1968; Legler & Georges, 1993). Nests are often in sandy to loamy soils with little vegetative cover. Disturbed areas such as road banks, railroad grades, cultivated fields, levees and dams are common nesting areas. Since female turtles lay eggs and then depart, there is no maternal care beyond lipid investment. Therefore, the characteristics of the nest environment will strongly determine the outcome of incubation. Temperature, moisture and gaseous exchange with a surrounding substrate will influence the size and survivorship of the incubating embryos. Thus, abiotic factors such as soil type and structure, aspect, slope, moisture, degree of vegetation and shading actually shape the prospects for a clutch of eggs. If any available substrate fulfills these requirements, then site selection is successful from a reproductive perspective, regardless of the specific type of substrate.

The present account's striking parallel to the nesting habits of emydid turtles in alligator mounds may be more than coincidental. *Emydura* are not abundant in areas that *C. porosus* occupy (G. Webb, pers. comm.) although *Emydura* have a long evolutionary history and distributional overlap with this mound-nesting crocodilian. *Crocodylus porosus* has a historical distribution southwards in Queensland that includes the Burnett River, although the southern populations have been extirpated for many decades. It is reasonable to ask whether Australian

turtles ever developed the practice of ovipositing in elevated nest mounds. If so, the practice is currently infrequent, even where crocodiles are now abundant. The behavior is rare enough not to be mentioned by the popular or technical literature for Australian turtles (Cann, 1998) or crocodiles (Webb & Manolis, 1989). From over two decades of monitoring *C. porosus* nests in the Northern Territory, there are four separate records of turtle eggs in crocodile nests (G. Webb & B. Ottley, pers. comm.). These were recorded in nests built upon floating mats in the freshwater swamps of the Finnis/Reynolds Rivers. In contrast, the co-occurrence of turtle eggs in crocodile nests is reported as reasonably common in Papua New Guinea (C. Manolis, pers. comm.; Cox, 1985).

Apart from the historical overlap with crocodiles, a less-speculative basis is probably more relevant to Sippel Weir. The prevalence of turtle nests in alligator mounds was strongly correlated with the level of variability in water levels (Enge *et al.*, 2000). In areas where water levels fluctuate markedly, changing water levels may promote the selection of a dry substrate to avoid nest inundation. The *Emydura* complex is widely distributed across the eastern and northern reaches of Australia (Georges & Adams, 1996). Chelids, in general, occur in environments characterized by extreme fluctuations of water level between the wet and dry seasons. Turtles that now inhabit dams or weirs would be expected to experience more stable water levels than those inhabiting un-regulated creeks and streams. However, the irrigation needs of a surrounding agricultural landscape may dictate a sudden change in water level from a draw-down or flood capture. This scenario is consistent with the timing of oviposition following a flood event at Sippel Weir.

Another contributing cause to the use of atypical nesting substrate may be the cumulative loss of former nesting habitat. Dams and weirs create flow-regulated reaches of river with lower flood pulses. The riparian zone receives fewer scour events that deposit sand

bars frequented by turtles as nesting banks. Rampant weed and grass growth are prevalent since most of the riparian zone at Sippel Weir is cleared for agriculture. Common invasive species in the Burnett Catchment include cat's claw creeper (*Macfadyana unguis-cati*), heart seed vine (*Cardiospermum grandiflorum*), lantana (*Lantana camara*), Para grass (*Urochloa mutica*), Noogoora burr (*Xanthium pungens*), thistles (Family Asteraceae), and castor oil plant (*Ricinus communis*). These weedy invasives form ground cover that is sufficiently dense to deter turtles from accessing sand banks. Where banks are not overgrown, barren patches of sand or earth are often created by free-ranging cattle. Vegetation-free areas are better suited to turtle nesting but trampling by heavy herbivores threatens the survival of any nests deposited there.

At first glance, *E. krefftii* has demonstrated a seeming adaptability in exploiting the novel nesting substrate. However, we suggest that the unusual choice may instead simply reflect its convenient access to a functional alternative after a loss or limited availability of suitable sandy patches.

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Fig. 1. Hay bales afloat in Joe Sippel Weir, Barambah Creek. Central depression is where *Emydura krefftii* nests were found. Photograph: A. D. Tucker

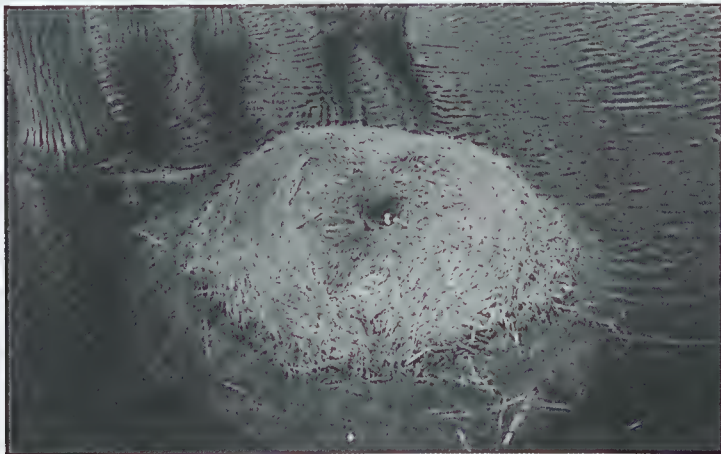


Fig. 2. Partially excavated nest of *E. krefftii*, exposing two closely situated but separate egg clutches on left and right sides. Photograph: A. D. Tucker



FATAL INGESTION OF A LARGE PREY ITEM IN THE SCRUB PYTHON (*MORELIA KINGHORNII*).

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INTRODUCTION

The Scrub or Amethystine python *Morelia kinghorni* (formerly *M. amethystina*; see Harvey *et al.*, 2000) is confined to eastern Cape York Peninsula where it occurs throughout the tropical tablelands and lowlands in rainforest, monsoon forests, vine thickets and adjacent woodland (Wilson & Knowles, 1988; Cogger, 1992; Ehmann, 1992). *Morelia kinghorni* is Australia's largest snake and in the wild it feeds on mammals including wallabies, pigs, fruit bats, rodents, bandicoots, and to a lesser extent on birds (Worrell, 1963; Shine & Slip, 1990; Ehmann, 1992; Loop *et al.*, 1995; Calvert, 1996; Greer, 1997; Fearn & Sambono, 2000a; see also Lethbridge, 1993). *Morelia kinghorni* has a reputation, along with a number of the larger pythons, for its ability to consume prodigious meals (Barker & Barker, 1994; Greer, 1997). This reputation has been embellished through the publication of photographs of *M. kinghorni* with enormously distended girths, the result of recently ingested prey items and of some individuals in the process of feeding on large prey (Waite, 1929:185; Frauca, 1978; Harrison, 1992; Brightman, 1993; Jago 1993:79 and cover; Greer, 1997:30; Austin & Storey, 1998; Willcox, 1999; Torr, 2000). Despite the potential hazards associated with subduing and consuming large prey items, there are no reports of *M. kinghorni* being physically injured as a result. In this note the fatal ingestion of a large prey item by a free-ranging adult *M. kinghorni* is reported.

OBSERVATIONS

On 13/9/99 a freshly dead adult *M. kinghorni* with a large recently ingested food item

situated mid-body was located by a local land-owner on the edge of a cane field, near Innisfail (146°01'E, 17°32'S), far north Queensland. The snake was noticed at the site the previous evening, apparently alive, though immobile, with an enormously distended girth. Weather conditions over the previous week had been warm and stable with daily maximums around 27°C while overnight minimum temperatures were around 16°C. Snakes had been observed active at night during that week around Innisfail (pers. obs.).

The snake was measured and then dissected. The following abbreviations of measurements are used below: SVL = snout-to-vent length, TL = tail length, HL = head length (as measured along midline from snout to posterior edge of the last head shields), HW = head width (measured at widest point), HD = head depth (from the posterior edge of the last head shields), HLL = hind limb length, CSL = cloacal spur length (HL, HW, HD, HLL, CSL measured using a vernier caliper; girths measured using a flexible tape measure).

The snake was an adult female with CSL = 3.5mm. The lower jaw was loose and clearly stretched in such a way that it overhung the upper jaw, and was dislocated from it. There was a conspicuous ventro-lateral skin fold extending from the head along the anterior third of the body apparently resulting from the skin being stretched during feeding. The snake's dimensions were: SVL = 2920 mm, TL = 500 mm, HL = 113 mm, HW = 57 mm, HD = 30 mm, Head girth = 150 mm, maximum mid-body girth = 490 mm. The undistended girth in the region immediately anterior to the prey item was 175 mm, and

posterior to, was 165 mm. This meant an almost three-fold (2.8) increase in the mid-body girth of the snake as a result of ingesting the prey item (using the average of these two values). A similar increase in the girth of the head (3.3 fold) would have been necessary to swallow the item. The skin at maximum girth was stretched to the extent that none of the scales were overlapping and the connecting skin was completely taut.

A ventral incision was made along the length of the snake. The prey item was determined to be an adult Red-legged Pademelon, *Thylagale stigmatica stigmatica*, which had been ingested headfirst and exhibited minimal decomposition. The pademelon was a mature adult female and was carrying a single juvenile in its pouch. The adult pademelon's dimensions were: HL = 125 mm, HLL = 142 mm; total length 910 mm (cf. 687-965 mm; Strahan 1995: 397-8). The juvenile was without fur and had dimensions: HL = 57 mm, HLL = 81 mm; total length 330 mm. No other prey items were present in the gut.

The total weight of the snake (accuracy ± 0.5 kg) and prey item before dissection was 10.5 kg. When the prey item was removed the snake was 5.0 kg and the pademelon was 5.5 kg (this is outside the quoted range of female weights: 2.5-4.5 kg in Strahan, *op. cit.*) but includes the mass of the juvenile). The mass of the pademelon and the snake were therefore very similar.

Around the stomach wall and in amongst the fur of the pademelon were thin (approx. 1 mm diameter) maroon-coloured nematode worms. A total of 17 nematodes were located, the longest being 58 mm. *Morelia kinghorni* and the marsupial prey that they feed on are known to be intermediate hosts for a variety of nematode worms which live in the gut of snakes (Cermak, 1993; Jones in Harvey *et al.*, 2000).

Externally there were no signs of physical injury and so the internal walls of the body cavity were carefully examined for possible

injuries that may have resulted in the death of the snake. There did not appear to be any abrasions or punctures, however fairly extensive internal haemorrhaging was evident in two localised patches adjacent to blood vessels below the vertebrae in the mid-body region where the prey item was lodged. No blood had leaked into the body cavity and the gut did not appear to be ruptured. Closer inspection revealed a single large blood vessel with several splits along its length. While it is not known for certain whether this injury alone had caused the death of the snake, in the absence of any other obvious signs of injury or abnormalities it seems likely.

DISCUSSION

The inclusion of pademelons in the diet of *M. kinghorni* is not surprising as they are commonly encountered on the edges of rain-forest and cane fields around Innisfail (*pers. obs.*) and have been recorded previously as prey of this species (Martin cited in Strahan, 1995: 397-8). Pademelons are known to make runways through ground vegetation and their activity extends from late afternoon through to early morning (Martin *op. cit.*). *Morelia kinghorni* is known to engage in ambush predation (Low, 1989; J. Weigel in Barker & Barker, 1994; Calvert, 1996; Fearn & Sambono, 2000b) and could conceivably exploit such runways in preying on pademelons. Diamond pythons *M. spilota spilota* are known to employ such a strategy in feeding on mammalian prey (Slip & Shine, 1988).

Morelia kinghorni is a relatively slender python for its length (Wilson & Knowles, 1988; Ehmann, 1992; Barker & Barker, 1994) and this characteristic makes its capacity to ingest large prey quite remarkable. There are several disadvantages in consuming large prey items however. First, the consumption of large prey would result in snakes having reduced mobility for a considerable period following ingestion. Jago (1993) reported that one *M. kinghorni* remained in the same position for at least six days after having ingested a large item. Reduced mobil-

ity might in turn make *M. kinghorni* more vulnerable to predators or expose them to unfavourable microclimates during the digestion process. Second, there is the risk of physical injury to the snake in both subduing, ingesting and then digesting prey (the regurgitation of large items would also present a risk). In this report it appears that the ingestion of prey proved fatal.

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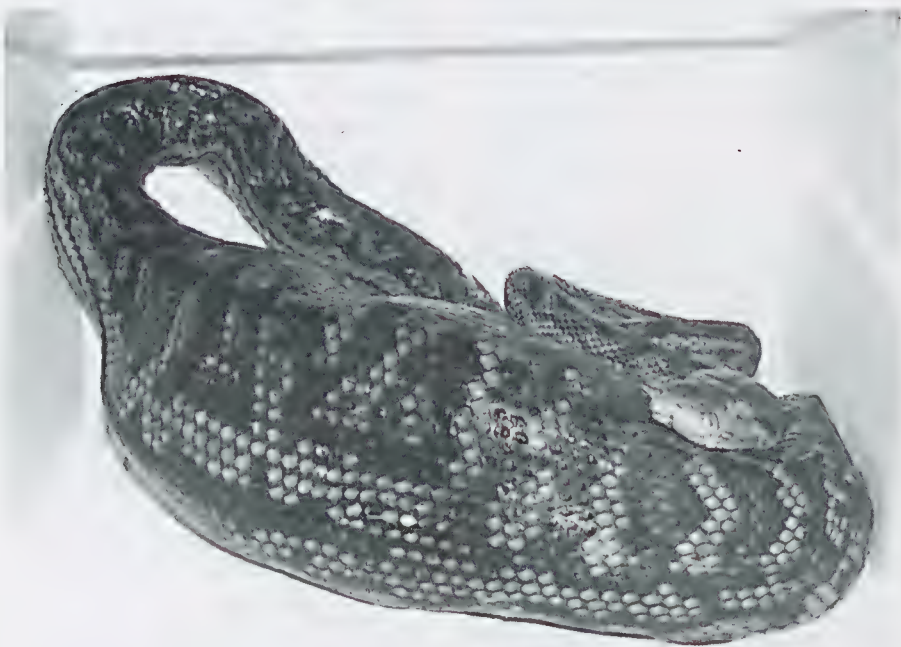
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Figure 1: The dead Scrub Python *Morelia kinghorni* containing the recently ingested Red-legged pademelon *Thylogale stigmatica stigmatica*.



MULTIPLE LIZARD SPECIES OCCUPYING THE SAME RETREAT SITES.

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INTRODUCTION

Observations of multiple species of reptiles and frogs occupying the same retreat are of interest because they represent examples of interspecific compatibility, indicate preferential retreat site selection, or the existence of a retreat site shortage in an area. There have been numerous reports of Australian reptiles and frogs occupying the same retreat however only a few of these describe aggregations of more than one species (e.g., Bustard, 1970; Covacevich & Limpus, 1972, 1973; Cogger, 1973; Covacevich, 1974; Rankin, 1975; Hoser, 1980; Maryan & Robinson, 1987; Valentic, 1993, 1996).

In this note we describe two separate occurrences of multiple lizard species occupying the same retreat. In both instances lizards occupied arboreal crevicolous retreats formed by decorticating bark around the bole of dead Eucalypt trees.

OBSERVATIONS

The observations occurred in June 1997 at two locations in northern NSW. Length measurements of lizards (snout-to-vent length: SVL; tail length: TL) were made using a rigid 500 mm ruler. The sex of adult geckos was determined by an inspection of the ventral tail base: males were characterised by the presence of conspicuously swollen pouches (housing the hemipenes), and adjacent to these, caudal spurs; females lacked both these features. The sex of adult skinks could not be reliably determined and therefore is not stated. Stage of maturity (i.e., adult, sub-adult, juvenile) are based on adult SVLs given for each adult species by Cogger (1992). The relative positions of individuals on the tree

bole were noted.

OBSERVATION 1.

Location: Dandry Road approx. 4 km in from Newell Highway (31°09'S, 149°21'E), 19 km north of Coonabarabran, north eastern NSW.

Habitat: 'Pilliga scrub' consisting of dense stands of Black Cypress-pine, *Callitris endlicheri*, mixed *Acacia* spp. and Eucalypt forest (Narrow-leaved Ironbark *Eucalyptus crebra*, White Box *E. albens*, White Gum *E. rossii*) growing on sandy loam soil plain.

Date: 23 June 1997. Time: 1450-1505 hrs. (EST). Weather: Cool and sunny; max. 19°C.

Notes: A large dead *Eucalyptus albens* (diameter approx. 0.7 m) beside a track was examined for the presence of reptiles. The main trunk of the tree was approx. 4 m in height, 2 m girth, with loose adherent bark 25-35 mm thick. Charred portions of bark indicated that it had been burnt in the last few years. Bark was easily removed (and later reattached with nails). During this process three lizard species (10 individuals in total) were located on the bole of the tree. The bole itself was slightly moist and all lizards were attached to the bole rather than the bark. Details of the lizards are as follows: Tree skink *Egernia striolata* - two adults (SVL 105 mm (both); TL 91 mm, 64 mm (22 mm of incomplete regeneration) and two juveniles (SVL 59, 58 mm; TL 66, 53 mm). Ocellated Velvet gecko *Oedura monilis* - two adults, a male (SVL 81 mm; TL 64 mm) and a female (SVL 80 mm; TL 62 mm, 51 mm regen. complete). *Diplodactylus williamsi* - four adult specimens; two males (SVL 62, 59 mm, TL 37 mm-1 mm of incomplete regeneration, 40 mm)

and two females (SVL 64, 66 mm, TL 40, 45 mm). Adult *E. striolata* and *O. monilis* were located at about the same height and within 0.3 m of each other, while juveniles and *D. williamsi* were widely separately and at various heights.

OBSERVATION 2.

Location: Pioneer Crossing, Gwydir River (29°25'S, 149°50'E), approx. 5 km north of Moree on the road to Mungindi, north eastern NSW.

Habitat: Floodplain immediately adjacent to the Gwydir river consisting of open grassy woodland with River Red gum (*Eucalyptus camaldulensis*) and Box Eucalypts dominant on disturbed alluvial soils with a degraded understory.

Date: 25 June 1997. Time: 1420-1510 hrs (EST). Weather: Overcast with intermittent sunshine; max. 18°C.

Notes: A large dead River Red gum (diameter approx. 0.8 m) on a small slope some 30 m from the rivers edge was examined. It was approx. 6 m tall with a 1.5 m girth, had flaking bark, and was completely exposed. Beneath the bark were adult *Cryptoblepharus carnabyi* which were very active. Two adult *Gehyra dubia* were observed higher up. In between the two *G. dubia* was an adult *Diplodactylus williamsi* which was about 0.5 m from either. Individual details of lizards were not obtained in this instance. There were a number of other large River Red gums in the vicinity with flaking bark, all of which had numerous active *C. carnabyi* on them.

DISCUSSION

While the importance of old or dead trees as roosting, nesting and shelter sites for birds and mammals is well known (Recher, 1984), there is much less known about their importance as refuges for arboreal species of reptiles. We found in each area that dead or mature trees with loose bark were used as refuges whereas younger trees that lacked

crevices between the bole and bark, or had very thin flaking bark, were rarely occupied. These 'preferred' refuges were uncommon at both localities and it seems that, in some instances at least, they take a considerable period of time to form. Senescent River Red gums, for example, are typically hundreds of years old. No reptiles were found on dead trees with flaking bark that were occupied by termites. Such trees were probably far less accessible to lizards due to termites using soil to plug gaps between the bark and bole. These observations concur with Bustard (1970) who stated the preferred habitat of *Egernia striolata* "...is free from dirt hence termites are habitat competitors". The same would also seem to be also true for the sympatric *O. monilis* and *D. williamsi*. Each lizard species was found to utilise other types of retreats within each habitat but in each instance occurred singly. Collectively these observations suggest that particular trees provide important habitat refuges for some lizard species.

A number of *Egernia* species are known to be gregarious, living in small 'family' groups (Greer, 1989; Ehmann, 1992; Hutchinson, 1993), and Bustard (1971) also found *O. monilis* to commonly occur in adult male-female pairs (this was observed above). Swanson (1987) states that *E. striolata* "...is usually found in family groups beneath loose bark of dead trees". In contrast, Bustard's (1970) study of Pilliga Scrub populations recorded adults occurring together on only five occasions (out of 250 sightings) and all occurred during the mating season in large home sites, however juveniles "quite frequently" occurred together with an immature or adult skink. Ehmann (1992: 242) notes that on smaller trees the species tends to be solitary but records a colony of eight found on an "old, large River Red Gum" suggesting that refuge size or availability may determine the occurrence of aggregations. We observed two further instances of cohabiting *E. striolata* near Uralla (30°38'S, 151°30'E) in the New England Tablelands: (i) a group comprising two adults and two juveniles and (ii) two

adults (plus an adult *Oedura tryoni*) beneath weathered exfoliating granite. The timing of these observations does not coincide with the species' known mating season (September-October, Bustard, 1970). Although few in number these observations suggest that associations between adult *E. striolata* are mediated by factors other than just mating.

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EEL AND TADPOLE PREDATION BY RED-BELLIED BLACK SNAKES.

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INTRODUCTION

All snakes are predatory but the range of prey items varies considerably between species. Some snakes prey on a few species within a taxon. For example, the Bandy Bandy *Vermicella annulata* appears to feed mainly on blind snakes (Shine, 1980) while others prey on a range of species across a range of animal groups. The Australian Red-bellied Black Snake *Pseudechis porphyriacus* belongs to the latter category (Shine, 1987).

The diets of Red-bellied Black Snakes have been documented for wild as well as captive animals. Prey items have been found to include mammals (Harlow & Shine, 1988), skinks (Adams, 1972; Rose, 1974; Shine, 1977, 1987), pygopods (Rose, 1974), agamids (Shine, 1977, 1987), other snakes (Shine, 1977, 1987; Webb and Rose, 1984; Torr, 1993), frogs (Adams, 1972; Shine, 1977, 1987; Craig, 1978) and fish (Le Souef, 1920; Burrell, 1925; Daly, 1992; Shine, 1977).

Predation of terrestrial animals by Black Snakes is usually stimulated by the movement and smell of the prey (Shine, 1977). The capture of tadpoles and fish, including eels, suggests a different hunting strategy may be employed in water.

OBSERVATIONS

Date: 18 November, 1999

Time: 12.20 EST (daylight savings)

Location: Wollombi Brook, The Basin, Olney State Forest, New South Wales. Easting 334680, Northing 6335580.

Habitat: Wollombi Brook is a permanent stream. It flows gently through an area of wet sclerophyll forest dominated by Blackbutt *Eucalyptus pilularis*, Sydney Blue Gum *E. piperita* and Black Wattle *Callicoma serratifolia*. In places, the stream-side vegetation has been cleared and grassed areas are present.

Species Observed: A 1.3 metre long Red-bellied Black Snake was observed on the edge of the brook in one of the grassed areas. The snake moved slowly along the bank until it found an area where it could submerge its head in the water. The snake probed the vegetation that was hanging in the water from underneath. When a tadpole was disturbed and attempted to swim off, the snake quickly pushed its head in pursuit of the tadpole, usually catching it. The snake raised its head above water, swallowed the tadpole and continued its underwater search. This behaviour continued for 40 minutes during which time the snake was observed to catch 18 tadpoles. Throughout this, the snake had at least half of its body out of water on the bank. The snake's tail was entwined around the base of a grass tussock to act as an anchor point while the snake's head was under water.

A selection of tadpoles were later caught with a dip net and were found to be those of the Leaf-green Tree Frog *Litoria phyllochroa*. Frogs were not seen along this section the creek during that day but later that night five species of frog were spotlighted in area. They were Leaf-green Tree Frog *Litoria phyllochroa*, Lesueur's Frog *L. lesueurii*, Blue Mountains Tree Frog *L. citropa*, Tusk Frog *Adelotus brevis* and the Common Eastern

Froglet *Crinia signifera*.

Date: 29 December, 2000.

Time: 16.20 EST (daylight savings)

Location: Boyters Lane, Pelican Island, Maclean River, North Coast New South Wales. Easting 503508 Northing 6579472.

Habitat: Pelican Island is a low-lying deltaic island formed by the anabranching of the Macleay River and Spencers Creek. The entire island is less than 10 metres above high water mark. The higher parts of the island have been cleared and converted into cattle pasture. Low-lying areas remain as either freshwater or brackish swamps. The area where the observation took place was on Boyters Lane which bisects the island. On either side of the road where the snake was found are freshwater swamps dominated by various sedges including *Triglochin*, *Schoenoplectus*, *Philydrum* and *Cyperus*.

Species Observed: A 1.2 metre long male Red-bellied Black Snake was observed in the process of swallowing an eel. The snake was on a grassy bank on the edge of a shallow swamp. When first seen, most of the eel was still in the water and squirming. The snake had already swallowed the head and was manoeuvring the rest of the eel down its throat when it was sighted. The eel continued to writhe and moved around until it was fully swallowed.

About 30 minutes later, I returned to the same area to find that the snake had recently been run over. The abdomen of the snake was split open and a long structure could be seen protruding through the split in the body wall. When the snake stopped moving, it was examined and the structure was discovered to be the head of a Long-finned Eel *Anguilla reinhardtii*. The eel, which was 95 cm long, was also dead but was not digested or damaged. No other prey items were present in the stomach.

The two freshwater swamps on either side of Boyters Lane contain frogs. A survey of the swamps that night detected a total of 7 frog

species and over 200 frogs being seen. The swamp on the northern side of the road contained *Litoria peronii*, *L. fallax*, *L. dentata*, *L. caerulea* and *Limnodynastes peronii*. The swamp on the southern side of the road contained *Litoria tyleri*, *L. fallax*, *L. dentata*, *L. latopalmata* and *Limnodynastes peronii*. Frogs were also seen jumping across the road at night.

DISCUSSION

The consumption of a wide range of terrestrial prey species is not unusual for elapid snakes as many front-fanged snakes are ambush predators and take prey opportunistically (Shine, 1987). Black snakes, however, will also actively seek prey and hunt sheltering and active animals (Shine, 1977). This tactic relies on the use of sight and smell to locate and capture prey. These senses while very useful for locating terrestrial prey are less useful in aquatic habitats where vision is impaired by the refractive index and the turbidity of the water and smell is diminished or lost completely.

Fish have been recorded in the stomachs of wild caught Red-bellied Black Snakes but these are uncommon. In a study of black snakes in the New England District of New South Wales, Shine (1977) found fish in the stomachs of only one Black Snake out of a sample of 119 animals. The fish that had been eaten was a River Blackfish *Gadopsis marmoratus*. Coincidentally, the same species of fish was present in the stomach of a black snake shot in the New England District in 1925 (Burrell, 1925). These fish are usually small (between 5 and 15 cms total body length), elongate and very sedentary. They are nocturnal and juvenile fish spend most of the time during the day under cover in the shallow margins of streams (McDowall, 1980).

Observations of Red-bellied Black Snakes eating eels have been made before (Daly, 1992). Unfortunately the method of capture of eels in the wild has not been observed. The eels could have been accidentally caught by

Black Snakes hunting for tadpoles and small fish sheltering under vegetation along the edges of a stream, or they could have been caught on land or approaching the water's surface near the bank. Eels will venture onto land at night and on overcast and wet days (McDowall, 1980). An eel encountered on land would have little chance of escape from a Black Snake whereas an eel in water would have a much better chance of eluding the snake.

Fish caught by Red-bellied Black Snakes may be an accidental by-catch of the pursuit for tadpoles. The tadpole seeking behaviour observed in Olney State Forest would startle other aquatic organisms sheltering under fringing vegetation. The flight movement appears to act as the stimulus for predation.

These observations question the importance of fish in the diet of Black Snakes and elapids in general. Barnett (1981) reported with some surprise that many snakes will readily feed on live fish in captivity. The elapids noted included Red-bellied Black Snakes *Pseudechis porphyriacus*, Spotted Black Snake *Pseudechis guttatus*, the Death Adders *Acanthophis antarcticus* and *A. pyrrhus*, Dugite *Pseudonaja affinis*, Western Brown Snake *Pseudonaja nuchalis*, Speckled Brown Snake *Pseudechis guttata*, the Tiger Snakes *Notechis scutatus* and *N. ater*, Copperhead *Austrelaps superbus* and the Rough-scaled Snake *Tropidechis carinatus*. Some of these snakes spend a lot of time around swamps and streams and would encounter fish on a regular basis; others (such as the adders) would be unlikely to ever encounter fish in the wild yet showed no reluctance in taking live fish.

The propensity of elapid snakes to eat fish has been used as a means of feeding captive snakes that will not eat mice or other captive prey items. Barnett (1981) recommended the use of fish as an important technique for feeding reluctant snakes. He further reported that colubrids and pythons also ate fish without hesitation. Banks (1987) further modified this technique by rubbing fish over pink mice and re-offering these to reluctant

snakes. He reported that the snakes readily took mice that they had previously refused after they had been treated with fish. This observation suggests that fish smell may serve a role in the choice of hunting site by Black Snakes in the wild.

These observations also suggest that fish feeding may be more widespread in snakes than is currently believed. For many snakes, however, the opportunity to catch live fish would be greatly limited. For many inland snakes, fish trapped in drying, shallow pools during drought years may be the only opportunity for them to catch or encounter fish.

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A NEW LOCALITY FOR THE RARE GREEN-THIGHED FROG (*LITORIA BREVIPALMATA*) IN SOUTH-EAST QUEENSLAND.

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INTRODUCTION

The Green-thighed Frog (*Litoria brevipalmata*) is a distinctive hyloid frog with an irregular distribution. It has been recorded from near-coastal habitats between Cordalba State Forest (Bundaberg region, 25° 10'S, 152° 10'E) in the north and Darkes Forest (34° 14'S, 150° 55'E) in the south (Hines *et al.*, 1999). Although widely distributed, this species remains known from relatively few sites throughout its range (Mahony, 1993; Nattrass & Ingram, 1993; Murphy & Turbill, 1999), even though additional populations have been located in the past five years as a result of increased survey effort and better understanding of the factors affecting detectability of the species (Hines *et al.*, 1999). This species is listed as Vulnerable in the NSW Threatened Species Conservation Act (1995) and Rare in the Queensland Nature Conservation (Wildlife) Regulation (1994). Tyler (1997) gives the national status of this species as insufficiently known and possibly of concern.

Breeding activity in *Litoria brevipalmata* has been noted as occurring between November and March in the southern part of its range (Tanton, 1996), with metamorphlings observed in south-east Queensland in February. This species is most frequently detected during breeding events which follow local flooding between October and April (Mahony, 1993; Ehmann, 1997; Lemckert, 1999). Lewis (2001) notes a recent sighting of this species during May in the Bungawalbin region of far north-eastern NSW, extending the known period of adult activity in this species.

This note documents an observation of *L. brevipalmata* in south-east Queensland in a previously unknown locality, adds to the current knowledge of the habitat requirements of the species and further extends the known period of adult activity.

OBSERVATION

On 1 July 1999 (2000 hrs) a single adult male *Litoria brevipalmata* (SVL 41mm) was collected from a flooded wheel-rut on a heavily eroded track in dry sclerophyll woodland dominated by Scribbly Gum (*Eucalyptus racemosa*), Pink Bloodwood (*Corymbia intermedia*) and Brown Bloodwood (*C. trachyphloia*). Geology is quaternary coastal sands overlaying Myrtle Creek Sandstone. The site is located adjacent to the Tewantin State Forest in coastal Noosa Shire (70°79'N, 50°3'E), and although subject to varying degrees of disturbance (i.e. selective logging and low intensity fire) remains relatively intact.

The woodland is characterised by a series of pronounced gullies which drain into swamp sclerophyll vegetation dominated by Broad-leaved Paperbark (*Melaleuca quinquenervia*). At the time of the survey these gullies supported flowing water and ephemeral pools.

The capture site was located on a ridge-top at approximately 25 m ASL. The flooded depression within the wheel-rut (2 m x 0.2 m) was approximately 0.5 m from the nearest dense cover, which consisted of an understorey of Kangaroo Grass (*Themeda triandra*), sedges (*Lepyrodis scariosa* and *Restio pallens*), a lily (*Tricoryne anceps*) and Sheath Rush (*Cyathochaeta diandra*).

This specimen was located following several days of heavy rainfall. No breeding aggregations were observed, despite the presence of apparently suitable waterbodies (i.e. ephemeral ponds in the dry woodland, ephemeral streams in gullies, flooded swamp sclerophyll forest and a small dam) and the individual was not calling. The frog was taken to the Queensland Museum where confirmation of the identification was provided by museum staff (G. Czechura, pers. comm. 1999) and was subsequently released at the point of capture.

The presence of the Wallum froglet (*Crinia tinnula*), a species known to occur in acidic water bodies (Ingram & Corben, 1975) at the site of the observation suggested that an investigation of water chemistry was warranted. Water and soil samples were collected from seven locations at the subject site and analysed to determine soil and water pH. Soil pH was found to range between 5.0 and 5.5 and surface water pH was between 4.6 and 5.2 at the time of the survey. It is considered likely that these pH levels were slightly elevated from normal background levels for the site as a result of heavy rainfall in the week preceding the survey.

DISCUSSION

This record represents the first sighting of *L. brevipalmata* in coastal Noosa Shire and the third coastal (i.e. within 10km of the coast) record of the species in the Sunshine Coast region. The broad habitat type where the specimen was recorded supports the proposal that dry sclerophyll forests may represent important habitat for this species in the northern part of its range (Lemckert, 1999; Murphy & Turbill, 1999).

L. brevipalmata has previously been recorded from former Wallum habitat near Beerburum, between the Sunshine Coast and Brisbane. Tanton (1996) cites a record of large numbers of *L. brevipalmata* from a 50 year old pine forest, with *Melaleucas* and pioneer

rainforest species. Surrounding habitat at Beerburum was noted as heathland and Scribbly Gum forest, indicating that the site was also located on low nutrient soils.

The apparent importance of dry forest types as habitat for this species does not imply that mesic forest types are of lesser significance in the region. Moffitt (pers. comm. 2001) recorded *L. brevipalmata* from subtropical rainforest at Buderim, approximately 32 km to the south of the site of this observation. Subtropical rainforest vegetation at the Buderim site is surrounded by wet sclerophyll forest, characterised by mesic species with emergent Flooded Gum (*Eucalyptus grandis*), Turpentine (*Syncarpia glomulifera*) and Blackbutt (*Eucalyptus pilularis*). This appears to be the easternmost record of *L. brevipalmata* in the Sunshine Coast region, situated approximately 2 km from the ocean (Alexandra Headland).

The period of adult activity of *L. brevipalmata* has previously been noted as between October–April (Ehmann, 1997; Lemckert *et al.*, 1997) with a recent record from late May (Lewis, 2001). This observation further extends the recorded period of adult activity to include July. It is noteworthy that the site had been surveyed on 28, 29 and 30 June 1999 without locating individuals or aggregations of *L. brevipalmata*. It is unknown whether breeding occurred at the site as no follow up surveys were undertaken.

Soil and water pH testing at the site, and the presence of a sizeable population of *C. tinnula*, suggest that *L. brevipalmata* is tolerant of moderately to strongly acidic conditions and therefore may be more widely distributed in nutrient poor coastal lowlands than generally acknowledged in the literature. Further surveys targeting *L. brevipalmata* are required in southeast Queensland and northern NSW to determine the significance of remaining coastal and near-coastal habitats.

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NATURAL HISTORY AND CAPTIVE MAINTENANCE OF THE NORTHERN BLUNTSPIINED MONITOR *VARANUS PRIMORDIUS*.

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INTRODUCTION

The Northern Bluntspined Monitor *Varanus primordius* is a poorly known lizard from northern Australia, with little published on its ecology. Contributing factors are its small size, secretive nature and limited distribution. It is not commonly maintained in captivity, and currently is held by two institutions and four private herpetoculturists, all in Australia. Unlike most Australian goannas, *V. primordius* has not yet become established in overseas collections.

Several adult pairs have been maintained at the Territory Wildlife Park for the past eight years with breeding successes attained in only the last three years. Due to the lack of interest from other institutions in maintaining this species, the Park has reached the stage where it will have to cease breeding or alternatively consider releasing excess offspring. The current policy of the Territory Wildlife Park is that excess animals are available only to Australasian Regional Association of Zoos Parks and Aquaria (ARAZPA) members but not to private herpetoculturists.

DESCRIPTION

Pale grey to dark reddish-brown dorsally with numerous scattered dark brown to blackish scales, which can be linked together to form a reticulated pattern. The dorsal scales may also be finely peppered with white edges. A faint temporal stripe is present and more prominent in males. The undersurface is creamy white to grey. The caudal scales are strongly keeled but not to the same degree as in *V. acanthurus* (Cogger, 1996). *Varanus primordius* may well be the world's second smallest varanid with adults rarely attaining 30 cm in total length.

DISTRIBUTION

Based on available museum records and reliable anecdotal reports, *V. primordius* is found from Darwin, south to the Katherine region, east to Kakadu and west to the Daly River region. One museum record from Keep River National Park was recently reidentified as *V. storri ocreatus* (P. Horner pers. comm.). The entire known range for *V. primordius* is currently an area of approximately 300km by 200km.

TAXONOMIC HISTORY

This species was described in 1942 as *Varanus acanthurus primordius* by the famous German taxonomist Robert Mertens, from a single specimen that was listed as being collected in Nord Australien (North Australia). It was amongst a small collection made by R. Schomburgk supposedly from near Adelaide, South Australia. According to Storr (1966), Schomburgk never visited northern Australia. Storr suggested that Schomburgk may have received the specimen from F.G. Waterhouse, a naturalist with the explorer Stuart on his crossing of the continent in 1861-1862.

Varanus primordius was known only from a single specimen until a further two were collected by A.M. Douglas and G. Storr 36 miles south of Adelaide River, NT, in 1964. This was a little over a hundred years after the holotype had been collected. These specimens apparently fuelled Storr's interest in the species and soon after he gave it full species status (Storr, 1966). *Varanus primordius* is still comparatively poorly represented in Australian museum collections with a total of only 34 specimens. The majority (24) are housed at the Museum and Art Gallery of the Northern Territory.

NATURAL HISTORY

Varanus primordius is commonly associated with low rocky outcrops in open tropical woodland. They live in shallow burrows beneath rocks on soil (Bedford & Christian, 1996). During the dry season they can be found on low-lying black soil floodplains, quite some distance from the nearest rock outcrops. It is assumed that as the wet season rains commence, the lizards retreat back to the security of the higher rocky country. In areas where they occur, often the first signs of the lizards beneath the rocks are a series of very well worn, shallow runways or trenches, often leading to the entrance of a small burrow. The burrows beneath the rocks are often only deep enough to accommodate the lizard's head and body, leaving most of the tail exposed. They occur amongst many different rock types, including granite, sandstone, limestone, shale, basalt and ironstone. Soil types also vary and include pale sand, laterite or black soil. *Varanus primordius* are also commonly found sheltering beneath discarded human building material such as sheet iron, wooden boards and fibre cement sheeting, most of it bedded well into the soil surface (pers. obs.).

These monitors tend to occur in what is sometimes referred to as loose colonies, one example being a group of 17 individuals (ranging in size from hatchlings to adults) found beneath rocks on a hill several hectares in size (G. Bedford, pers. comm.). On one occasion only has the author found more than a single animal sheltering beneath an item of cover, and that was an adult pair found under a sheet of iron. They appear to have a patchy distribution but are quite common where they occur. *Varanus primordius* are very secretive lizards and in the 12 years the author has resided in the "Top End", only two animals have been observed active, both mature adults. One was basking in the centre of the Stuart Highway between Pine Creek and Katherine, while the second was observed crossing a dirt access road at the Territory Wildlife Park (pers. obs.).

Wild *V. primordius* have been recorded feeding on ants, orthopterans, lacewing larvae, reptile eggs and lizards (Losos & Greene, 1988). While collecting *V. primordius* from the wild, several lizards regurgitated recent meals. Food items included a centipede, a cockroach and a cricket. Skink scales have also been observed in the faeces of recently captured animals (pers. obs.).

Populations in most areas appear stable if not secure, although encroaching urban development in the Darwin and Palmerston regions poses a serious threat in these locales.

CAPTIVE MAINTENANCE

HOUSING

Exhibit

At the Territory Wildlife Park, a male and female are kept on display at all times. These animals are exchanged periodically with "off display" animals, primarily to give all lizards the opportunity to access a larger, more naturalistic enclosure.

The exhibit is constructed from compressed fibre cement sheeting, with a fine wire mesh top for ventilation. Keeper access is via a hinged front-opening glass door. Approximate exhibit dimensions are 120 cm L x 60 cm W x 120 cm H. Heating is provided by two 250 watt reflector globes, one suspended directly above the wire mesh top, and the other inside, attached to the cage ceiling. The latter creates a "hot spot" of around 50°C and a hot rock is also partially buried in the substrate for additional heating. Lighting is provided by two 60 cm fluorescent tubes, a BL "black light" and a "white light", suspended above the mesh top. The photoperiod is 12 hours on and 12 hours off, controlled by a timer. Landscaping consists of a combination of real and artificial rocks, arranged in such a way as to create a series of crevices and retreats. The substrate is sandy soil with a light covering of leaf litter. A single living grass tussock is the only plant. A small, concealed ceramic bowl is provided for water.

Off display holding

The adults are housed individually in holding cages constructed from 12 mm plywood with front-opening wooden framed glass doors (not recommended for such fast moving lizards). The cage dimensions are 72 cm L x 32 cm W x 37 cm H. The top and both sides have large areas of perforated metal screen for ventilation. Heating is provided by a single 40 or 60 watt (depending on time of year) reflector globe, attached to the inside of the cage ceiling at one end, to provide an adequate thermal gradient. The "hot spot" directly beneath the globe is maintained at around 40°C. Lighting is via a single 60 cm BL "black light" on top of the cage. Photoperiod is as above and the substrate is fine red desert sand. A piece of curved bark is provided for cover, a small rock is placed directly beneath the heat lamp as a basking site and a small ceramic bowl provided for water. Juveniles are housed in plastic tubs or glass aquaria, set up in a similar way to the holding cages. The first week after hatching they are kept on paper rather than sand, to avoid accidental ingestion. Adult males cannot be housed together as, if given the opportunity, they will seriously maim or even kill each other. We suspect a newly introduced female was killed by a female cagemate. This behaviour is also typical of wild caught *V. storri*, a close relative of *V. primordius* (M. Vincent, pers comm.).

HUSBANDRY

Enclosures are spot cleaned and the water changed every second day. The substrate is entirely changed every few months. As heated cages have the tendency to become dry, water is added to the substrate every couple of days to elevate humidity. This alleviates skin shedding problems.

A two-compartment wire mesh sun box with a wooden frame, approximate dimensions 60 cm x 30 cm x 60 cm, is used to give the animals occasional exposure to natural ultra-violet radiation for several hours at a time. It is used on a rotational basis, so that all specimens benefit and is thought to be beneficial

in maintaining their long-term health.

Adults are fed two to three times weekly, the food items being dusted with calcium D₃ supplement every second time. Captive cultured black crickets and wood roaches make up the staple diet. Current practice at the Park is to remove the barbed rear legs from the crickets before feeding to alleviate the risk of injury to the lizard's mouth. The reduced activity of the crickets also allows the calcium powder to stay on the cricket a lot longer. Juveniles are fed the same as the adults with the food being dusted more frequently.

SEXING

Determining the sex of adult *V. primordius* is relatively easy. Comparatively, males tend to have a larger head, are more heavily built and more colourful, and the dorsal scales have a more rugose appearance. Males also achieve a greater size. The largest male in the collection at the Territory Wildlife Park is 119 mm snout-vent length and weighs 32.8 g while the biggest female is 111 mm snout-vent length and weighs 24.8 g. Females also have a tendency to bite, while males are not as aggressive. Surprisingly for such a small lizard, the bite is extremely painful, raising the question about the properties of the saliva. Juveniles start to develop obvious sexually dimorphic characteristics at several months of age.

BREEDING

Varanus primordius have been maintained at the Territory Wildlife Park on a continual basis since early 1993. The first clutch of eggs was produced two years later but it was not until late 1998 that the first hatching success with healthy offspring occurred. From April 1995, three females have produced nine clutches and a total of 30 eggs, of which 14 have hatched. Clutch size has varied from two to five eggs (mean = 3.3, sd = 1.12, n = 9 clutches from three females if infertile "slugs" are included; mean = 3.4, sd = 1.06, n = 8 if only shelled eggs are counted).

As mentioned previously there are always a pair of animals housed together on display. Four clutches have been layed in this exhibit; one clutch of four eggs however desiccated.

The off display animals are kept individually for the majority of the time and only paired for breeding. They are placed together for 24 to 48 hours maximum, with the male normally losing interest after the first few hours. Courtship observed has been typical of small monitors, with many fast jerky head movements and vigorous tongue flicking from the male while pursuing the female around the cage. Copulation normally takes place out of sight beneath cover. Our current practice has been to bring the female to the male to minimise male disturbance.

Gestation is brief and ranges from 14 to 21 days. Once the female is gravid, she spends a lot of time basking beneath the heat lamp. A day or two before oviposition, she will excavate several shallow "test" holes before constructing a much deeper nesting burrow. Egg laying normally takes place in the late evening. Two litre plastic ice cream containers, filled with moist sand and with several entry holes cut in the top, were offered as possible egg laying sites for the first two gravid females. These were ignored and the eggs were layed in the dry substrate. When it is certain the females are gravid, extra sand is added to the enclosure. This is mounded in the cooler end of the cage to a depth of around 15cm, and kept moist.

EGG LAYING

As soon as egg laying has been identified, the eggs are located and removed. They are weighed and measured and placed in the incubator. The incubator used is a human humidicrib donated by a local Darwin hospital. A number of different incubation mediums have been used including vermiculite, red desert sand and perlite, and mixtures of these. The vermiculite and perlite tend to hold the moisture considerably longer when sand is mixed in. Due to frequent high humidity levels in Darwin, the water is gener-

ally mixed into the medium by feel rather than ratio. The first two clutches were incubated at an average temperature of 31°C. It is possible that a combination of too much moisture and high temperature contributed to the eggs reaching full term but failing to hatch. With the exception of one egg from clutch (f) (see Table 1) that was incubated at room temperature (range 24-35°C) and hatched and died at three days of age, all other eggs were incubated at 28.5 to 30.5°C with good results.

Two litre icecream tubs are used as incubation containers. They are filled approximately 2/3 with incubation medium. Clear plastic lunch wrap held in place with elastic bands is placed over the top of the container to retain the moisture. This is subsequently removed for a short period every few days to allow for oxygen exchange. At about 60 days into incubation, a few small holes are pricked in the plastic, for better oxygen exchange. The eggs are half buried in the medium, so their condition can be assessed at a glance. The incubation period ranged from 87 to 120 days. See Table 1 for details of egg size and dates of oviposition.

HATCHLINGS

The first animal to hatch from clutch (f) emerged on 17 November 1998 and was the cause of much elation. This was short lived, as the animal died three days later, after suffering a series of violent convulsions. This animal hatched from the egg that was incubated at room temperature and as it is possible that exposure to such a high maximum temperature was the cause of its demise. The author has since experienced a similar case with *V. baritji* eggs. One animal from clutch (e) had short soft horn like projections protruding from the nape region. It was also small, failed to thrive and was eventually euthanased. Upon hatching the neonates are weighed and measured and set up in appropriate containers. Paper towel is used as substrate for the first week and kept damp for the first few days to prevent dehydration. The young are housed together for as long as

Table 1 - Eggs

	Clutch/Date	Mass (g)	Length (mm)	Width (mm)
Female 1	(a) 30.04.95	1.3	19.0	10.5
		1.3	18.0	11.0
		1.3	18.5	11.0
		1.3	19.0	11.0
	(b) 12.11.95	Desiccated (4 eggs)		
	(c) 04.10.96	Desiccated		
		1.7	21.0	12.5
		1.7	21.0	12.0
	(d)	Desiccated slugs (2)		
	(e) 04.10.99	1.9	20.0	10.0
		1.8	20.0	10.0
		1.9	20.0	10.0
		Slug		
Female 2	(f) 16.08.98	2.2	25.0	12.5
		2.2	25.5	12.5
	(g) 23.09.98	2.4	25.0	13.0
		2.2	24.0	12.5
Female 3	(h) 05.09.01	1.7	19.5	12.5
		1.7	20.5	12.0
		1.7	19.5	12.5
		1.8	20.	13.0
		1.6	20.	11.0
	(i) 07.10.00	1.4	20.5	11.0
		1.4	20.0	11.0
		1.4	20.0	11.0
		1.5	20.5	10.5
	Minimum	1.3	18.0	10
	Maximum	2.4	25.5	13
	Mean	1.7	20.8	11.5
	sd	0.33	1.12	1.01
	n	22	22	22

Table 2 - Hatchlings

Clutch	Mass (g)	SVL (mm)	Tail length mm)
(e) 02.02.00	1.0	41.0	57.0
	1.5	41.0	54.0
(f) 17.11.98 -	2.1	48.0	64.0
14.12.98	2.0	47.0	59.5
(g) 27.12.98 -	2.0	50.0	66.0
04.01.99	2.3	49.0	59.5
(h) 01.12.00 -	1.4	42.0	51.0
03.12.00	1.2	42.0	54.0
	1.5	41.0	55.0
	1.2	44.0	55.0
(i) 15.01.01 -	1.4	42.0	55.0
16.01.01	1.2	41.0	49.0
	1.4	43.0	56.0
	1.4	45.0	55.0
Minimum	1.0	41	49
Maximum	2.3	50	66
Mean	1.5	44.0	56.4
sd	0.40	3.23	4.58
n	14	14	14

possible and then moved to individual holding containers. Small crickets are offered and normally accepted at about 2 to 3 days. Post-hatching growth is governed by food intake and temperature. Sexual maturity can be reached at 9 to 12 months. See Table 2 for measurements of hatchlings.

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AN OVIGEROUS ARGUS MONITOR, *VARANUS PANOPTES PANOPTES*.

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Data on seasonality of reproduction and clutch size are few for many species of large Australian monitors, due to a combination of a sex ratio of captured lizards highly skewed towards males, paucity of space for storing large preserved monitors in museum collections and the difficulty in breeding such large lizards in captivity. Shine (1986) provided the first data on reproduction in wild Argus Monitors, *Varanus panoptes panoptes*, reporting clutches of 9, 11 and 13 eggs in dissected females without dates of collection, and a female with enlarging ovarian follicles collected in February. He also reported presumed courtship on two dates in July. These data were subsequently also reported by James *et al.* (1992), who gave the earlier paper as their source, although listing reproductive females as collected in both February and March, and by Greer (1989) and Bennett (1998). More recently, Blamires (1999) reported two females in May, one with regressed ovaries, the other with five enlarged ovarian follicles, another female with seven shelled eggs in April (reported as being in the ovaries, presumably erroneously), a male with enlarged testes in July, and very small hatchlings in October ($n = 2$), January ($n = 1$) and February ($n = 2$). The April female was also reported by Blamires and Nobbs (2000). Vincent and Wilson (1999) reported a clutch size range of 6-14 (sample size not given) and the discovery in August of a clutch of nine eggs, which hatched between October and November. As they also report an incubation period of 210-356 days (sample size not given), this would suggest that the eggs were laid sometime

between October and March.

Given the paucity of data on reproduction in this taxon, the following observations are valuable.

On 4 April 1994, we collected an ovigerous female *V. panoptes panoptes* (Australian Museum R143873) at 17km NW of McKinlay Creek on the Landsborough Hwy, Queensland, in 21°10'S 141°09'E. The lizard was euthanased and preserved as a skeletal preparation on 6 April, at which time she had a fresh total mass of 1420g. Unfortunately, snout-vent length was not recorded prior to skeletonising. Eleven fully-shelled eggs, with lengths of 55-63mm, were present in the oviducts, and are preserved wet along with the skin and visceral organs.

These observations provide only the fifth definite date of collection for a reproductive female, and the second such record of an ovigerous animal. As it is likely that oviposition would have occurred within a few weeks of collection, our data suggest oviposition in May. Although the sample sizes and seasonal distribution are at present very limited, the data are consistent with a pattern of autumn to winter (early/mid dry season) mating and oviposition, with hatching in spring to summer (late dry season to wet season). This pattern also accords with observations of females ovipositing in April and neonates appearing in October at Northern Territory University (G. Bedford, pers. comm.). The interval between these times is towards the shorter end of the range of incubation periods reported by Vincent and Wilson

(1999). Further data are needed to confirm this pattern of reproductive seasonality.

ACKNOWLEDGMENTS

The goanna was collected under Queensland National Parks and Wildlife Service permit T01074. We thank G. Bedford for his additional observations.

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A RECORD NUMBER OF EGGS LAID BY AN AUSTRALIAN NATIVE FROG SPECIES.

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INTRODUCTION

In a table listing published data on the eggs and tadpoles of Australian species of frogs, Tyler (1994) reported the egg complements of 65 species. Subsequently Anstis (1994) reported one further species (*Litoria brevipalmata*).

The maximum number of eggs laid by a single native species was 7,000 in *Cyclorana australis* and the second highest 3,000 in *Litoria caerulea* (Tyler *et al.*, 1983). Egg deposition by the introduced Cane Toad, *Bufo marinus*, is 8,000 - 25,000 according to Zug and Zug (1979).

Here we report the egg complement of an individual of *Litoria splendida* in which ovulation was induced in the laboratory.

OBSERVATIONS

At 4.30 pm on 27th March 1996 an adult male and female *Litoria splendida* were each injected with 10 micrograms (0.1 ml of a 100 microgram/ml solution) of luteinising hormone releasing factor (LHRH) manufactured by Sigma. The LHRH was injected into the dorsal lymph sac following the technique described by Tyler (1996). The pair joined in amplexus after 90 minutes, and the process of oviposition commenced at 8.50 pm.

Eggs were laid in clumps of approximately 60 - 100; the extrusion of each clump lasting approximately 15 seconds. By 1.00 am on 28th March a total of 5,210 eggs had been laid. Between 1.00 am and 7.00 am a further 4,793 eggs were laid and the

pair then separated.

On 30th March a further 370 eggs were found in the aquarium bringing the total laid to 10,363.

DISCUSSION

The female upon which the above observations were made had been maintained in captivity for 20 years, and had not bred during that period. It follows that it is possible that the record egg complement was high because it represented the accumulation of eggs from several years. Watson and Gerhardt (1997) did not report the egg complements of females observed in the wild and noted that "it is possible that successful reproduction in *Litoria splendida* is a relatively uncommon event". There is a belief amongst some herpetologists that eggs not laid during one season are resorbed. We have been unable to trace a reference in the literature in support of this belief, and our observations suggest that it is false and that, in the absence of breeding, the eggs simply accumulate.

We have no data to suggest how many years' spawnings the total may represent.

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NOCTURNAL ACTIVITY OF A DIURNAL SKINK, THE EASTERN BLUE-TONGUE (*TILIQUA SCINCOIDES*)

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20 Erang Ave, Kirrawee, NSW 2232.

The Eastern Blue-Tongue (*Tiliqua scincoides*) is generally recorded as diurnal in the literature (Greer, 1989; Swan, 1990; Cogger, 2000). The following observation of nocturnal activity of one individual is offered as an exception to the normal diurnal behaviour.

OBSERVATION

On 6 December, 1999 at 2130hrs, I was drawn to the noise of movement among some fallen leaves at the bottom of my backyard at Kirrawee (34°10'S 151°04'E), a Sydney suburb. I then observed by torch-light, a single adult Eastern Blue-Tongue (about 300mm in total length). At the time, the weather conditions were dry, overcast and warm (temperature 22°C). On that date, sunset was at 1956hrs, and moonrise was at 0437hrs.

The area in question was in total darkness, well away from artificial lighting, and had a great amount of low thick plant growth. There was no moonlight. When the torch-light fell on the lizard, it moved more quickly and appeared to be uninjured and not engaged in any unusual activity (e.g., mating or giving birth). The lizard was alert and my presence appeared to disturb it, as it moved quickly away from me. I could not see any particular reason for the blue-tongue to be active, such as unusual stresses or unusual environmental factors. The noise I heard that drew me to find the blue-tongue was similar to that of a lizard moving in a normal fashion.

The next day, a blue-tongue of identical appearance to the one seen the previous

night was found within 3m. It appeared uninjured and in good health apart from some tick infestation. It looked to be the same lizard, although I cannot be certain.

DISCUSSION

I have not observed nocturnal activity by a blue-tongue previously, and the only other literature record I am aware of is a single observation of *Tiliqua scincoides* active at midnight on a hot summer evening at Tibbooburra following a very hot day (P. Rankin in AHS, 1982).

I regard the weather conditions on the day of my observations as somewhat unusual in that the overcast conditions, temperature and absence of wind were relatively consistent from 1500-2200hrs. In particular, the temperature did not drop appreciably after sunset.

It may be that my observation is of atypical behaviour or, given the apparent scarcity of similar observations, it may be limited to very restricted weather conditions. Other questions that may be asked relate to the benefits of this type of early evening activity in a normally diurnal lizard. Could it be to avoid predation by birds? Could it be an advantage in seeking some food sources? And are there any particular weather or environmental conditions, not always obvious, that may prompt it?

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HERPETOLOGICAL NOTES

ERRATUM

Volume 31 Number 1, July 2001 page 49

"A RECORD OF HIGH FROG SPECIES DIVERSITY FROM THE MITCHELL GRASSLANDS OF SOUTHWESTERN QUEENSLAND"

by R.A. Palmer and S.A. Pidcock

Omitted one species from Table 1. Under the heading *Myobatrachidae* should be inserted the species: *Crinia deserticola* Chirping Froglet Abundant.

BOOK REVIEW

THE HERPETOFAUNA OF NEW CALEDONIA.

By Aaron M. Bauer and Ross A. Sadlier, 2000.
322pp., 47 maps, 63 figs., 189 colour photographs.

Published by the Society for the Study of Amphibians and Reptiles.

R.R.P. US\$60.00 + postage. ISBN 0-916984-55-9

(orders to Robert D. Aldridge, Dept of Biology, Saint Louis University,
3507 Laclede, Saint Louis, Missouri 63103, U.S.A.)

The Herpetofauna of New Caledonia is a magnificent contribution to the herpetological literature. Containing 310 pages of text, 189 colour photographs, keys and superbly detailed descriptions, this book is a thorough overview of New Caledonia's herpetofauna. It is the synthesis of 20 years of research by the authors, both eminently qualified to collate a volume of this nature. Bauer and Sadlier have contributed to the descriptions of 38% of the terrestrial reptiles known from New Caledonia.

New Caledonia is home to rich, highly endemic plant and animal communities - a classic biodiversity 'hotspot'. And for those who love reptiles, these islands are a Pandora's box of oddities. This book includes both terrestrial and marine herpetofauna. It covers extant species including many new discoveries, and startling rediscoveries; the poorly-known / possibly extinct fauna, and the subfossil and fossil taxa. Here, we find the world's largest gecko and a massive skink, both with a taste for other vertebrates, the fossil remains of a giant, horned tortoise and a terrestrial, mollusc-eating crocodile.

The Herpetofauna of New Caledonia is far more than a herpetological text. The authors place the fauna in a biogeographical context, discussing the factors that have shaped the face of modern New Caledonia and its faunal communities - a complex interplay between geological history, geography, vegetation and humans. Like all

island faunas, the animal communities of New Caledonia are fragile and easily disrupted. The reptiles of New Caledonia have long suffered the effects of humans, through exploitation, habitat destruction and the introduction of alien biotas. The megafauna were the first to go - pushed to extinction, following human contact 3500-4000 years ago.

The history of the European discovery of New Caledonia and description of its herpetofauna is summarised, from the early explorations of the 18th century to the research of the 19th and 20th centuries. The exploratory phase of New Caledonian herpetology is ongoing, with the recent discoveries of many new species.

To the museum worker, the avid naturalist and the reptile photographer alike, this book is nothing short of a godsend. Here, in a single volume, are generic and specific keys to the entire herpetofauna of this unique region. Each key is accompanied by superb line-drawings that leave no room for ambiguity in the characters discussed. The benchmark for assessing any key is whether it steers the user to the correct identification. These keys do just that. Ten lizard species, randomly selected from the Queensland Museum's reference collection were tested, by me, against these keys. I achieved a correct identification in all cases. The keys are followed by detailed species accounts, with information on distribution, natural history and conservation

status. A remarks field in many of the accounts is particularly useful in highlighting genetic affinities, clarifying nomenclatural histories and providing useful information not included under the main headings.

This book is superb - well ordered, well illustrated and immensely useful. It caters for French-speakers through summaries of the major text blocks and accompanying keys. It can be used as an atlas, with its maps and gazetteer providing the precise coordinates for 196 place names mentioned in the text. And, perhaps most importantly, it is a window to the broader literature, with a bibliography containing almost 1000 references. I am constantly

revisiting this text, marvelling at the attention to detail. And while the authors modestly regard their book as 'provisional at best', the same is true of any natural history text. While there is still much to learn about the composition, relationships, distribution and biology of New Caledonia's herpetofauna, we are now much closer to unravelling these mysteries. *The Herpetofauna of New Caledonia* is a quality work, which will be the standard text for many years to come.

Patrick J. Couper,
Vertebrate Zoology,
Queensland Museum.

NOTES TO CONTRIBUTORS

Herpetofauna publishes articles on any aspect of reptiles and amphibians. Articles are invited from interested authors particularly non-professional herpetologists and keepers. Priority is given to articles reporting field work, observations in the field and captive husbandry and breeding.

All material must be original and must not have been published elsewhere.

PUBLICATION POLICY

Authors are responsible for the accuracy of the information presented in any submitted article. Current taxonomic combinations should be used unless the article is itself of a taxonomic nature proposing new combinations or describing new species.

Original illustrations will be returned to the author, if requested, after publication.

SUBMISSION OF MANUSCRIPT

Two copies of the article (including any illustrations) should be submitted. Typewrite or handwrite (neatly) your manuscript in double spacing with a 25mm free margin all round on A4 size paper. Number the pages. Number the illustrations as Figure 1 etc., Table 1 etc., or Map 1 etc., and include a caption with each one. Either underline or italicise scientific names. Use each scientific name in full the first time, (eg *Delma australis*), subsequently it can be shortened (*D. australis*). Include a common name for each species.

The metric system should be used for measurements.

Place the authors name and address under the title.

Latitude and longitude of any localities mentioned should be indicated.

Use the Concise Oxford Dictionary for spelling checks.

Photographs – black and white prints or colour slides are acceptable.

Use a recent issue of *Herpetofauna* as a style guide.

A computer disc may be submitted instead of hard copy but this should not be done until after the manuscript has been reviewed and the referees' comments incorporated. Computer discs must be HD 1.44 mb 3.5" in Word for Windows; Wordperfect; Macintosh or ASCII. Any disc must also be accompanied by hard copy.

Articles should not exceed 12 typed double spaced pages in length, including any illustrations.

REFERENCES

Any references made to other published material must be cited in the text, giving the author, year of publication and the page numbers if necessary. At the end of the article a full reference list should be given in alphabetical order. (See this journal).

Manuscripts will be reviewed by up to three referees and acceptance will be decided by an editorial committee. Minor changes suggested by the referees will be incorporated into the article and proofs sent to the senior author for approval.

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REPRINTS

The senior author will receive 25 reprints of the article free of charge.



Dorsolateral and Ventral views of unusual *Adelotus* from the Carnarvan Ranges.
See paper on page 97. (Photos: K. Griffiths)